A TOTAL PRODUCT STRATEGY

CAPACITOR AROCLOR

CONFIDENTIAL

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I. The Market Situation

A. The Total Market for Capacitors

The annual value of capacitor production in the USA in 1966 will be over 400 million dollars. It is expected to grow to 425-450 million dollars by 1968.

For better understanding, this broad total market is broken into the following general capacitor uses:

Industrial (those which use Aroclor)

1. Air conditioning, motor running
2. Fluorescent lighting
3. Power line factor correction

Industrial and Electronic

1. Energy storage
2. High voltage DC power supplies
3. Electrolytic capacitors for industrial motor starting and also for electronic uses

Electronic

1. Government defense, physics and research
2. Instruments
3. Tuning and filtering
4. Communications

The attached table gives the type capacitors and their specific purposes to fulfill the different segments of each general market category.

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TABLE 1

375 TO 400 MILLION DOLLAR CAPACITOR MARKET (1963)

MILLIONS OF DOLLARS

Category	1963	1964	1965	1966	1967	TYPE CAPACITOR	MARKET PURPOSE
INDUSTRIAL	9	9	10	10	11	Aroclor 1242 (AC)	Air conditioning, motor running
INDUSTRIAL	12	12	13	13	14	Aroclor 1242 (AC)	Fluorescent lighting
INDUSTRIAL	18	18	19	19	19	Aroclor 1242 (AC)	Power line factor correction
INDUSTRIAL ELECTRONICS	3	3	4	4	4	Aroclor 1242, 1254 and castor oil	DC, Energy storage
INDUSTRIAL ELECTRONICS	5	5	6	6	7	Aroclor 1242, 1254	DC, High voltage power supplies
INDUSTRIAL ELECTRONICS	56	58	63	65	68	Aluminum Electrolytics	Motor starting and electronics
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	67	70	71	71	72	Tantalum & Molybdenum, Electrolytics	Mainly Government defense markets
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	0.4		0.5		0.7	Zinc & Aluminum Metalized kraft paper	Use poly iso butylene and in Europe, castor oil
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	20		25		30	Metalized or free foil, Mylar - Teflon	Highly reliable (dry) units fast growing market
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	35		37		40	Titanium-Barium-Zirconium	Very high capacitance small size (solid)
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	25		25		25	Mica-Glass & Vitreous	High reliability - steady market for MICA
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	89		91		94	Paper film - plastic molded-wax impreg.	Inexpensive, wide general use
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	0.5				0.8	Dibutyl sebacate and adipate, Al. Plate capacitors	High frequency - specialty water cooled
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	0.7				0.7	Halowax-chlorinated naphthalene	Inexpensive, specialty
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	-				-	Silicone Oil	High temperature specialty little used, too costly
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	0.5				0.5	Mineral Oil, largely replaced by Aroclor	Now used only as specialty for DC requiring flat DK temperature relation
ELECTRONIC, INSTRUMENT, TUNING & COMMUNICATIONS	40		42		44	Variable Air Condensers	Wide use for tuning
Totals	$381				$431		

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B. The Market for Aroclor Capacitors

Aroclor capacitors are useful in the following market categories:

	Capacitor Value (Domestic Only)	
Industrial	1965	1969
1) Air conditioning	$10,000,000	$14,000,000
2) Fluorescent lighting	13,000,000	15,000,000
3) Power factor correction	19,000,000	25,000,000
Industrial & Electronic		
1) Energy storage	4,000,000	5,000,000
2) High voltage DC power supplies	6,000,000	8,000,000
Total	$52,000,000	$67,000,000

Thus, Aroclor capacitors used primarily for industrial purposes controlled about 50 million dollars of the total capacitor market in 1965 with projected growth to $70,000,000 by 1969.

Several overseas areas represent important markets for capacitor Aroclor. Most important of these are Canada, Europe, Latin America and Japan. Over the past few years, total sales have been $200,000 - $400,000 per year with Canada being our most consistent market.

For a complete look at the global markets for capacitor Aroclor together with marketing plans for the major areas of the world, refer to, "The World Wide Strategy for Capacitor Aroclor" dated May 1, 1966.

C. Capacitor Aroclor Sales Forecast (Domestic USA plus Export)

Actual past sales and the forecast for world-wide capacitor Aroclor are as follows: (Aroclors 1242 and 1254)

Year	Pounds of Aroclor
1957	15,669,290
1958	12,902,340
1959	15,139,470
1960	16,091,745
1961	16,074,940
1962	15,405,095

Year	Pounds of Aroclor
1963	16,000,000
1964	20,500,000
1965	22,500,000
*1966	23,500,000
*1967	24,900,000
*1968	26,400,000
*1969	27,130,000
*1970	27,760,000

Since capacitor Aroclor sells at approximately 15¢/lb., about $3,000,000 of Aroclor is used to make capacitors valued at about $60,000,000. Thus, in general, the market value of our fluid represents only about 5% of the market value of Aroclor capacitors.

D. Major Customers for Capacitor Aroclor

The principal Monsanto Company customers for capacitor Aroclor are:

Company	Location	Annual Purhcase Pounds
General Electric	Hudson Falls,N.Y.	7,500,000
Westinghouse Electric	Bloomington, Ind.	4,000,000
Aerovox	New Bedford, Mass.	1,500,000
Cornell Dubilier (Federal Pacific)	New Bedford, Mass. & Newark, N. J.	1,500,000
Sprague	N. Adams, Mass.	1,500,000
Line Materials	Milwaukee, Wisc.	1,000,000
Electronic Components	Bridgeport, Conn.	1,000,000
Sangamo	Pickens, S. C.	600,000
Electrical Utilities	LaSalle, Illinois	600,000
Ohio Brass	Mansfield, Ohio	500,000
P. R. Mallory	Crawfordsville, Ind.	300,000
Canadian General Electric	Peterborough	600,000
Aerovox Canada, Ltd.	Hamilton	300,000
Canadian Westinghouse	London	150,000
ITE Circuit Breaker	Port Credit	100,000

Most of the capacitor Aroclor is produced at Anniston, Alabama, whereas most of our business is in the Northeast and North-central states. A potential competitor located in the Northeast would have a substantial advantage in freight since freight costs amount to nearly 9% of Aroclor sales prices.

E. General properties and specific market factors that dictate the use of Aroclor capacitors

A history of the development of capacitors and the use

of Aroclor in capacitors is given in Appendix A. This is important to the understanding of our products and markets.

An Aroclor capacitor is merely a roll of aluminum foil conductor interwound with kraft tissue insulation, contained in a metal can, vacuum impregnated with Aroclor, and then permanently sealed. There are no moving parts and no maintenance to be done.

Unlike the transformer industry, the selection of Aroclor for capacitors is not based primarily on the fact that Aroclor is fire-resistant. It is true that Aroclor is the only capacitor fluid that offers maximum safety to protect people and surroundings - and this is important.

However, it is the combination of dielectric properties and economics that has permitted Aroclor to maintain a dominant position in fixed-paper industrial capacitors over the past 35 years.

Possessing high capacitance relative to very low insulation loss factors, excellent dielectric strength, remarkable oxidative and thermal stability, and a relatively low cost, Aroclor has not been replaceable and is used exclusively in its established capacitor market areas. Although priced near $2.00 a gallon, Aroclor capacitor dielectric has almost completely eliminated use of mineral oil (the past standard) priced at only 65 cents a gallon.

The economic advantages of Aroclor are not obscure. Because the dielectric constant of Aroclor is at least twice as large as the 2.2 value for mineral oil, an Aroclor capacitor half the size of a mineral oil unit will do the same work. The savings accrued, by using only approximately half as much paper, aluminum foil and container, offsets by a considerable margin the higher cost of Aroclor fluid.

However, this excellent fixed-paper capacitor is suitable for use only in certain applications - as shown in Table I. Entirely different capacitor systems are used to fill the many other large capacitor requirements.

A discussion of the most important markets for Aroclor capacitors together with the factors affecting these markets is given in Appendix B.

F. Forces Acting for Monsanto Aroclor in Capacitors

1. In spite of considerable effort to find something better, Aroclor has remained the standard dielectric in fixed-paper capacitors for over 35 years. On the basis of performance and cost, no one (including Monsanto) has been able to beat Aroclor. Aroclor is still the product of choice. It is unlikely that this position will change in the foreseeable future. Any new product would have to show considerable advantage over Aroclor because:

   a. It is costly to set up separate or new production lines in existing capacitor factories. Thus, manufacturers prefer not to handle another material unless it can completely replace Aroclor.

   b. The capacitor manufacturers are reluctant to handle different dielectric fluids in the same plant. They don't even like to buy Aroclor from two producing sources - we ship almost everything from Anniston. This desire acts to our advantage versus some possible competitive manufacturer of Aroclors.

2. The great confidence and reliance which our customers have in Monsanto's ability to produce and deliver very high quality products - temporarily shaken in 1956 but all okay today.

3. The experience and technical service which Monsanto offers the capacitor manufacturer and his customers. We have been able to assist in problems involving storage, contamination, impregnating and handling and equipment designs. In addition, through the introduction of thermal and chemical stability tests, we have been able to assure the customer of the very highest quality material and provided him tools whereby he can check this quality prior to use.

4. The very high quality of Monsanto Aroclor is a force acting for us. This quality establishes another hurdle for competition - makes it a little harder for someone else to enter the business.

5. Through cooperative activities in technical societies such as ASTM, Electrochemical Society, American Institute of Electrical Engineerings, the National

Electrical Manufacturers Association, we have established Monsanto as a professional partner in the capacitor industry and have been able to ~~influence~~ specifications and test procedures ~~to our advantage~~.

6. Prudent pricing has been and will continue to be a most important force for Monsanto Aroclor.

7. The fire resistance of Aroclor certainly acts for us. Although safety is not as important in the selection of Aroclor for capacitors as it is in transformers, it is important.

G. Forces Acting Against Monsanto Aroclor in Capacitors

1. Continued interest (mostly at G.E.) in finding a new dielectric fluid to replace Aroclor or an additive to be used with Aroclor to further decrease capacitor size and lower cost. We do not feel that either type of program will be successful in the foreseeable future. G.E. has developed a new capacitor using plastic film as a partial replacement for paper. This will reduce the amount of Aroclor used in certain capacitors by about 25%.

2. We are the only domestic producer of Aroclor. Patents have expired and other companies do consider the possibilities of producing chlorinated biphenyl - especially Dow, Stauffer, Koppers, and Hooker. Good field intelligence, prudent pricing, top-quality product and technical service leadership are our best insurance against competition (see Plans & Strategies).

3. The capacitor industry troubles in 1956 partially blamed on Aroclor and the tests used to evaluate Aroclor, could be considered a force which acted both for and against us. It caused G.E. to doubt our ability to produce and define consistent top-quality product. To say the least, they were very unhappy with Monsanto and actually sought another source of supply. The fact that they were unsuccessful acted for us since it demonstrated to G.E. that our pricing policies had been fair in spite of our position as sole supplier. Technically we all came out ahead since new thermal and chemical stability tests were developed which more accurately defined the quality of Aroclor. We have re-established industry confidence in Monsanto's capabilities to produce the very best quality products. Relations with G.E., Westinghouse and others are excellent.

4. Monsanto product quality is not as good as that available from Bayer or Prodelec. This difference is small but can be important in a competitive market. Today this only involves certain export markets but longer range could affect a domestic position, actions are underway to correct this.

H. People Who Influence the Choice and Use of Aroclor Capacitors

Strange as it may seem, only the capacitor manufacturer has any influence in the choice of liquid dielectrics used in capacitors; and today, his only logical choice for fixed paper capacitors based on performance and cost is chlorinated biphenyl. For the user of industrial fixed paper capacitors, Aroclor is the only thing available; and this is not likely to change unless the capacitor manufacturer finds something better. There are no outside influences on the market other than improved technology or another producer of chlorinated biphenyl. These influences are discussed in other sections of this report.

I. Competition

Monsanto's basic patents expired around 1950; but, thus far, no one else in the USA has produced electrical grade Aroclor. Fair pricing, top-quality products, and technical service leadership are responsible for our continued position as the only domestic producer of Aroclor.

Chlorinated biphenyl is produced in England, Germany, France, Italy, Japan and Russia. Thus far, foreign material has not entered this country, and it is not likely to in the future.

Complete details of competitive activity have been developed - country by country - as part of a global marketing strategy and certain area strategies.

Additional details on the domestic competitive situation regarding Aroclor are contained in Appendix C.

J. Pricing Strategy

The historical pricing of Aroclor is given in Appendix D.

A study of Appendix D together with information presented in Section I-C indicates the following conclusions and strategy:

1. Depending upon the size and type of capacitor, the cost of the Aroclor in the capacitor represents 5-10% of the market value of the capacitor. Thus, the market demand for capacitor Aroclor is not highly price sensitive, and we cannot increase our sales by simply reducing price.

2. Increasing the price of Aroclor as much as 25% would have little effect on total sales.

3. We do not anticipate any change in the price of Aroclor used in capacitors unless there are changes in the price of raw materials or freight.

4. We will change Aroclor prices if a price change in benzene, chlorine or freight totals $0.20 cwt. in terms of Aroclor price.

5. In overseas markets our domestic prices will be used. If a legitimate competitive lower cost is offered, we will meet it.

K. Importance of our Production Capacity

Monsanto is the sole supplier of chlorinated biphenyl in this country. Originally all production was at Anniston, but during the War when the government insisted on another source Monsanto was fortunate in being able to satisfy this essential requirement by producing at WGK. Today, both facilities are needed to furnish Aroclors for transformers and capacitors.

These electrical apparatus are essential to maintain our normal living and for our defense in cold or hot war. Assuming this responsibility of single source of supply requires that we maintain a larger excess capacity than is required of most products. A minimum of 25% excess capacity of required quality product should be available at all times.

A recent expansion should provide this excess capacity for 1966 and 1967, but new facilities will be required to meet forecasts beyond 1967 (and provide the agreed upon excess capacity).

Additionally, we must maintain an adequate tank car fleet to deliver the Aroclor when and where the customer wants it. To replace obsolete cars and build up our fleet needs, 34 new aluminum cars are being purchased at a cost around $600,000 - delivery mid 1966.

II. Long Range Objectives

A. Increase the sales of capacitor Aroclor from 23,500,000 pounds in 1966 to 27,800,000 pounds by 1970 - at maximum profitability.

B. Establish a world-wide marketing program designed to provide top-quality products, the very best technical and commercial service and research and analytical assistance. Our purpose is to maintain our supply position in the domestic market and increase our business in selected overseas markets.

C. Investigate possible new technology which will enhance and protect and position of Aroclor in industrial capacitors.

III. General Strategy

Aroclor 1242 is used as a dielectric in fixed-paper capacitors because it offers the best combination of cost and performance to do the job. Many other products have been over the past 30 years, but none offers the total performance of Aroclor. We know of nothing on the horizon which will challenge this position.

Fixed-paper capacitors with Aroclor are widely used in the market for capacitors used in industrial applications. These units fill a special market need and are always specified for the various applications where they are used. In other words, the user does not consider Aroclor units versus some other type - when he needs a specific type of industrial capacitor, he always buys an Aroclor fixed-paper capacitor. The same is true of other types of capacitors filling other specialized needs. For technical reasons, Aroclor will not compete in other markets, and thus other types of capacitors are specified (see Table 1).

Because Aroclor fixed-paper capacitors fill a specific need and are always specified for that need, there is very little that we can do to increase the use of Aroclor in capacitors. We cannot influence the total requirement for industrial capacitors. However, there is a great deal that we can do to maintain our present position.

The following items are an important part of our general strategy for capacitor Aroclor.

A. To increase the sale of capacitor Aroclor from 23.5 million pounds in 1966 to 27.8 million in 1970 - at maximum profitability.

   1. Provide the necessary high quality electrical grade Aroclor in the amount required to meet the expected growth for the fixed-paper Aroclor capacitor markets. The entire industry depends exclusively on Monsanto to fill these needs - we are their sole supplier. Make certain that the quality of Monsanto Aroclor is at least as good as competitive material produced in other world areas.

   2. Maintain absolute leadership in sales and technical service on capacitor Aroclor to capacitor manufacturers, other component suppliers, and end use customers. Plan an offensive service program

(especially technical assistance) and solve defensive problems (especially with the customer) as they arise.

3. Induce all customers to employ the new modern testing tools for determining the thermal and chemical stability of incoming Aroclor.

4. Encourage the use of thermal stability procedures to probe the quality of capacitor components such as the resistors, tabs, foil, paper, gaskets, rim seal compound, and the can metals - when heated in the presence of Aroclor. Through this approach, get customers to screen out components now considered acceptable. This will "lock-in" Aroclor and lead to better quality capacitors.

5. Attend technical society meetings to keep posted on possible new developments and assist in the preparation of specifications and test procedures for capacitor materials. In the past ASTM was concerned with only establishing test methods for materials. Now this authoritative group is also responsible for posting the material specification requirements to meet the needs of the given industry. Accordingly, the ASTM committee is now drawing up and will publish official industry specifications for capacitor Aroclor. No lieniency will be shown on the very tight quality requirements - which through its years of progressive efforts Monsanto has demonstrated its capability to meet.

6. Cooperate with the International Division to provide technical assistance to selected world markets.

7. Forecast accurately future requirements for Aroclor in order to maintain at least 25% excess capacity to handle demand surges.

8. Appraise the effect of possible new dielectric developments by others (additives, films, etc.).

9. Continuously appraise our capability to develop marketable improvements in the Aroclor dielectric for across-the-board capacitor uses.

10. Investigate new markets, such as EHV transfer of electricity, to see if Monsanto can play a role in market development.

IV. 1966 Goals

A. Sell 23.5 million pounds of capacitor Aroclor (domestic and U. S. export).

B. Request analysis by the Product Director of possible competitive manufacture. Since the availability and cost of biphenyl is such an important consideration in any competitive action, make a thorough analysis of other possible sources of biphenyl and its effect on chlorinated biphenyl production costs.

C. Visit WGK and Anniston at least twice to review quality control, future activities and capacity needs.

D. Make at least two calls on all our major capacitor Aroclor customers.

E. Make trips to Canada, Europe, Mexico, South America and Australia as required, to help the electrical industry properly use our electrical grade Aroclor.

F. Follow all the listed market use areas for indications of expansions or contractions and forecast accordingly.

G. Analyze the increased demand for Aroclor that will result from the large new power capacitor requirements for EHV lines, and revise forecasts accordingly.

H. Evaluate the effect of the new G.E. Slimvar 400 KVAR plastic film capacitor on future Aroclor requirements and establish marketing and research plans accordingly.

I. In the ballast market areas, domestic and international, evaluate the effect of G.E.'s new Pyranol-2 and establish marketing and research plans accordingly.

J. Explore the status of outside developments designed to raise the capacitance of Aroclor 1242 by additives such as cyanoethyl sucrose.

K. As Aroclor consumption has increased markedly and will surge strongly late in 1966, implement projects designed to provide a larger and more satisfactory tankcar fleet.

L. Accomplish improved electrical properties to meet world-wide competition. This specifies raising the resistivity from 500 x 10^9 ohm-cm. at 100°C. to

10,000 for Aroclor 1254 and 6,000 for Aroclor 1242. It specifies power factor of 0.2% at 100°C. and 60 cycles for Aroclor 1254 and 0.5% for Aroclor 1242.

M. Arrive at standardization on electrical measurements between Anniston, WGK, MCL, and the customers.

N. For international shipments, establish biphenyl content maximum of 0.025% for Aroclor 1254 and 0.05% for Aroclor 1242.

O. To meet superior thermal and chemical stability of competitive chlorinated biphenyl, the maximum chloride levels related to various stability tests must be lowered considerably to 0.25 ppm. or less.

P. To meet competitive and domestic industry requirements for transformer askarels the old resistivity specification of 100×10^9 ohm-cm. is to be raised to 1,000 and a power factor of 1.5% at 60 cycles and 100°C. is tentatively assigned.

Q. Determine need for and definition of a research program designed to develop new generations of dielectric fluids to replace or improve Aroclor.

R. Assist our customers to evaluate the diepoxide type scavenger for capacitor Aroclor.

S. Assist in updating strategies for Mexico, Canada, Brazil, Argentina, Australia, Europe and others as required.

T. Establish quality improvements at WGK so that we can have complete interchangeability of shipment to all customers between WGK and Anniston.

U. Improve the electrical properties of Aroclor 1242 as packaged in drums - particularly for overseas customers.

V. 1966 Market Plans

A. Maintain present exclusive supply position in domestic markets.

Responsibility	Action	Review Date or Target Date
PGB, GRB, Purchasing	Note changes in raw material costs (benzene and chlorine) and adjust prices according to pricing strategy.	Continuously
JC, Mfg.	Evaluate any new developments which would affect possible competitive manufacture.	2nd and 4th Quarters 1966
PGB, Field Salesmen	Visit major accounts at least twice to provide technical service. Field salesmen visit each major account at least six times during the year.	During 1966
PGB	Attend ASTM and IEEE meetings to ~~develop~~ assist specifications, test procedures, ~~and to project Monsanto image~~ in this ~~market~~.	Through 1966

B. Improve quality so that our product is at least as good as foreign competition.

PGB, JMC, Mfg.	Agree on new target quality specifications	1st quarter 1966
JAM, Mfg., Engineering	Determine necessary actions, timing and costs to improve quality to meet new spec.	2nd quarter 1966
JC, Mfg., Marketing	Approve actions and costs to improve quality and get projects underway.	2nd quarter 1966
Mfg., Eng.	Start producing material to consistently meet new specifications.	2nd quarter 1967

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Responsibility	Action	Review Date or Target Date
Mfg., Mktg.	Establish both WGK and Anniston as equally capable of producing new quality and obtain customer agreement to take material from either plant.	2nd quarter 1967
PGB, Mfg., MCL, R. Munch	Agree on test procedures to measure quality.	3rd quarter 1966

C. Assure 25% excess production and shipping capacity over annual requirement.

Mktg.	Review long-range forecasts.	1st quarter 1966
Mfg., Eng., JC	Determine timing of need for new facilities, prepare projects and submit to management for approval.	3rd quarter 1966

D. Evaluate the effect of new technical developments on the use of Aroclor in capacitors.

PGB	Define the value of epoxide additives and establish plan by which Monsanto can make maximum contribution.	3rd quarter 1966
PGB, GRB	Evaluate value of Pyranol P-2 additive and attempt to get license from G. E. if desirable.	3rd quarter 1966
PGB	Evaluate future effect of use of plastic films in capacitors on Aroclor business.	3rd quarter 1966
PGB	Define the importance of cyanoethyl sucrose to the Aroclor capacitor business.	4th quarter 1966

E. Evaluate need for Research program in capacitor Aroclor.

Responsibility	Action	Review Date or Target Date
PGB, Dev. Research	Define areas in which Research effort is required.	3rd quarter 1966
WR Richard Mktg., Mfg., JC	Develop program to implement needs in the Research area and obtain approval for manpower and money.	4th quarter 1966

F. Provide assistance in Global Marketing program.

PGB	Make tech service trips as required to Canada, Mexico, South America, Europe and Australia.	Through 1966
PGB, Int.	Assist in preparation and implementation of Area Strategies.	Through 1966
PGB, GRB, Int.	Review Global Strategy	2nd quarter 1967
JAM, MCL	Prepare process improvement plan for Aroclor, biphenyl and chlorine at MCL	4th quarter 1966
JAM, JC MCL	Implement plan to improve MCL costs.	During 1967
Int. Div.	Prepare Marketing plans for major export markets - Canada, Mexico, South America, Australia, etc.	4th quarter 1966
RAS, GRB	Study manpower requirements for better local marketing effort in selected export markets and make recommendations accordingly.	3rd quarter 1966

G. Improve the delivered electrical quality of Aroclor 1242 - particularly packaged in drums to overseas customers

Mfg.	More highly refine to upgrade electrical properties before packaging to meet new specifications.	2nd quarter 1966

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Responsibility	Action	Review Date or Target Date
Mfg.	Select a new drum capable of maintaining electrical properties. Investigate innovations such as add earth to the drum.	2nd quarter 1966

APPENDIX A

HISTORY OF CAPACITOR DEVELOPMENT

600 BC - Capacitance is one of the three basic parts of an electric circuit. Around 600 BC, it was recorded that an amber rod rubbed with a piece of fur would then attract and cling to fur, feathers, etc. This was the first experimental proof that it is possible to store and release electrostatic energy.

1745 - Nothing further happened along this line until 1745 when similar observation was made using a jar filled with water and a nail stuck through the wooden cover. The operator's hand was the other electrode of this device called the Leyden Jar.

1746 - Refinement of this, by placing tin foil inside and outside of the jar to serve as the electrodes and the glass walls of the jar to serve as a good dielectric, resulted in the first capacitor construction. This is what Ben Franklin charged with his flying kite, but the gadget remained a play thing until 135 years later.

1878 - A paper capacitor impregnated with paraffin was made for a telegraph circuit.

1892 - A capacitor was tried for a single phase alternating current motor.

1914 to 1929, the era of mineral oil - Finally in 1914 it was concluded that capacitors could be made for the purpose of power factor correction to save money. It was foreseen that capacitors on the power line would decrease the amount of electric current supplied at one end of the electrical system to get the desired work done at the other end.

Paraffin wax used to impregnate these early capacitors had short life. This led to discovery of the refinement of mineral oil to give better performance.

At this time Charles P. Steinmetz, of General Electric Company, aroused his associates by predicting large future commercial use for this strange device, still called a condenser. Use was forecast for:

1. power factor control
2. induction motor starting
3. as a circuit protective device

While he did not foresee air conditioning, fluorescent lighting, nuclear plasma, etc., unquestionably the fix-paper, mineral oil impregnated capacitor had arrived for significant commercial use.

In those days "Trouble Was GE's Most Important Product." Use of the new mineral oil impregnated paper capacitors contributed more than their fair share of trouble and problems.

Probably noted more for high failure rate than anything else, use of these capacitors was hazardous as their failure involved an intense exothermic reaction, recognized more commonly as an explosion.

The tin foil electrodes dissolved in the mineral oil after short use and the linen paper contained an amazing amount of impurities, including pearl buttons.

Aluminum foil replaced tin giving marked improvement, and allowed making a 5 KVAR power capacitor - indeed a large unit for those days. However, this also performed poorly until experience emphasized need for much more care in drying and impregnating operations.

But this was far from enough. The problems were so great that G. E. hired their first organic chemist, Frank M. Clark, to study the nature of mineral oil, etc. Seeking high purity oil, highly refined, water-white mineral oil was adopted, only to find that this ionized under voltage stress forming a very troublesome deposit, called "X-wax" because no one knew its composition.

After several years work the white oil was replaced with a (less pure) higher aromatic content oil, but it was known that something better would have to be found. Commercial use demanded not only much better performance but already emphasized the need for significantly lower costs.

Fortunately, Kraft paper was discovered. Coming from trees, it was clean and free from the bits of contamination resident in linen cloth. Use of Kraft paper greatly encouraged the capacitor makers to continue, but in time they again got disgusted with the myriad of problems.

Things were ripe for the coming great discovery.

THE DISCOVERY OF AROCLOR 1254 DIELECTRIC BY FRANK M. CLARK OF GENERAL ELECTRIC CO.

1929 - Theodore Swann, an aggressive, enthusiastic, and venturesome businessman of our country's early chemical era, had provided the first facilities to produce biphenyl for heat transfer. The anticipated market promptly flopped. The main trouble arose from biphenyl's relatively high melting point causing all of the pipes in the heater system to be frozen at normal temperatures. Wisely, Swann began chlorination of biphenyl as the easiest and least expensive approach to getting derivatives with possible useful and salable properties. This resulted in the great spectrum of interesting properties possessed by the new family of chemicals called Aroclor.

Frank Clark quickly tried these new materials and found them to be good dielectrics. Moreover, they were unique because of their oxidative, thermal and chemical stability - and, of all things, they did not burn.

Frank patented their use and assigned the G. E. tradename Pyranol (R). For this discovery, he won the coveted Coffin Award of G. E. in 1932. His invention is designated by the World Almanac as One of the World's Great Inventions and Scientific Discoveries.

The Pyranol Basic Use Patents:

1. USP, 1,931,455, application April, 1931, issued October, 1933. Covers chlorinated biphenyl, chlorinated benzene and chlorinated biphenyl ether.

2. USP, 2,041,594, application April, 1931, issued May, 1936. Covers chlorinated biphenyl, chlorinated biphenyl ether and mixes with chlorobenzenes.

3. USP, 2,341,760, application February, 1942, issued February, 1944. Covers halogenated biphenyl benzene mixed with halogenated castor oil.

1932 - The advantages of Aroclor 1254 over mineral oil were so great that by 1932 nearly all capacitor manufacturers were licensed by the Clark patents to use this new material. It allowed cutting the capacitor size in half - a great economic advantage - and additionally Aroclor lent itself nicely to sales promotion activity because of its unusual quality of not burning.

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However, the new capacitor dielectric soon showed a disadvantage. While producing more capacitance, which resulted in building much smaller units, lack of adequate heat-transfer area required finding a better design to dissipate this heat.

This lead to development of the "cross-roll" design for the capacitor core and allowed making a 15 KVAR Aroclor unit - no larger than had been a 5 KVAR mineral oil capacitor.

This great success was heralded by the advertising people who proclaimed that "Now capacitors like Ivory Soap are 99 44/100% pure, and look here, folks, we can't get the liquid to ignite with this blow torch."

1935 - 1951 - Through this period the Aroclor 1254 capacitor market use grew continuously.

It was helped by development of a special Kraft paper which allowed increase in the capacitance rating from 15 to 25 KVAR. This also paved the way for low density paper, which later was an important factor in allowing construction of 50 and 100 KVAR units.

THE ERA OF CAPACITOR AROCLOR 1242

1952 - Just like discovery of Aroclor 1254 back in 1930 resulted in the almost total replacement of mineral oil - around 1952 the "discovery" of Aroclor 1242 resulted in almost complete replacement of Aroclor 1254.

This last transition which brought significant economic advantage to the capacitor industry transpired practically unnoticed at Monsanto because all that was needed was to chlorinate to 42% instead of 54% (an easier operation).

As Aroclor 1242 was always as readily available as Aroclor 1254, it is of interest to note reasons why its advantages were not used for so many years.

Its advantages are better low-temperature properties, about 12% greater capacitance than Aroclor 1254, and it is significantly lighter in weight. Sold at the same price per pound, the combination of greater volume at the same weight cost plus greater capacitance allowing smaller, less costly construction adds up to economical advantages near 20%, depending on the particular type capacitor.

While the industry was always aware of this, they had evidence that Aroclor 1242, a thinner more polar dielectric, might not be handled satisfactorily. This false premise was dedicted from the fact that the industry indeed had trouble at times handling Aroclor 1254 and hesitated to face the fact that this was due to lack of sufficient "cleanliness" in the capacitor plants.

As power lines capacitor switching came into vogue to gain the most efficient possible use and also as fluorescent lighting was moving outdoors - there arose need for a superior low-temperature dielectric for such applications in the colder climates. Aroclor 1242 met these requirements.

Also around this time, the fierce price squeeze began, and the capacitor makers looked hard for ways to cut costs. Westinghouse made the initial move to use Aroclor 1242 to solve both of these problems. The result has been that all others have had to follow.

As was anticipated, almost all of the capacitor makers ran into contamination problems on switching to Aroclor 1242. Monsanto assisted in solving these problems. Today, these factories operate in the required "clinically clean environment" and the transition to Aroclor 1242 is almost complete.

1956 - Historically, 1956 was the only time that the quality of Aroclor has been seriously questioned. Possibly this and other materials used in construction resulted in the capacitor failures that swept our country at great loss to the capacitor manufacturers - especially G. E.

1959 - By this time, dependable improvements in both the quality of Aroclor and Kraft paper paved the way for the industry to cut the size of power capacitors in about half and sell at much lower prices.

1966 - Throughout this historical gamut of capacitor events, Aroclor constantly emerged in a stronger position. Today, capacitor Aroclor 1242 is "a tremendous buy."

In recent years competitive economic pressures amont the capacitor manufacturers resulted in constantly making smaller size Aroclor capacitors to do the same work as before at less cost. This has kept our capacitor Aroclor sales on a relative plateau instead of fully sharing the intrinsic ever growing use for Aroclor capacitors. Fortunately this cutting of the standard Aroclor fixed paper capacitor designs ended in 1966, and various standard type designs are now being enlarged for better performance.

However, research done only at General Electric Company has resulted in their marketing Pyranol 2 ballast and motor-run capacitors wherein the Aroclor 1242 contains a diepoxide stabilizer. The purpose is to underwrite General Electric's objectives to continue making the smaller harder working capacitors. This is covered by British Patent 986,950 and U. S. application No. 223,691.

Additionally, in 1966 General Electric introduced their Slimvar 400 KVAR power capacitor containing Aroclor 1242 but with a highly stressed plastic film replacement for a portion of the Kraft paper, normally used. This is the first time that more than 100 KVAR's have been packaged in one can and obviously the new Slimvar 400 unit accomplishes significant size reduction. It cuts the Aroclor content by more than half. Pending anticipated commercial success this Aroclor capacitor containing plastic film will again result in enhancing the economic value of Aroclor fluid for capacitors.

COMMERCIAL ATTEMPTS TO REPLACE AROCLOR

It is beyond the scope of this writing to list the hundreds of chemicals explored as possible replacements for Aroclor. Practically all sought to accomplish greater economies via the higher capacitance route. However, God seems to have ruled that with higher capacitance comes higher loss factors. Certainly this has been the prime reason for failure of most of the candidates to replace Aroclor for capacitors. Yet there will always be an interest in the possibility of adding a relatively minor amount of a high dielectric constant material to Aroclor in order to shave costs.

Since the advent of Aroclor 1254 use in 1932, replacement attempts that attained commercial attention are listed very briefly as follows:

1938 - Tetrachlorotoluene: This wax is unusual because its dipoles rotate in the solid state. However, instability precluded its use.

1944 - Chlorinated castor oil mixed with chlorinated biphenyl benzene: While neither compound alone was of interest, surprisingly their mixture showed possibility until lack of stability ruled it out.

1947 - Biphenyl sulfone: This was one of the early examples of a relatively high dielectric constant material that seemed of interest as an additive to Aroclor. However, due to higher polarity it was too difficult to "clean-up" and handle without excess trouble from contacting trace contaminants.

1948 - Trichlorobiphenyl ether: A good dielectric but too high in cost.

1949 - Although General Aniline and Film received U.S.P. 2,211,019 in 1940 covering dimethyl-diphenyl sulfone, claimed to have a DK greater than 11.5 - and in 1946 G. E. received U.S.P. 2,410,714 covering dinapthyl sulfone for mixture with Aroclor and mineral oil - active commercial interest did not develop until 1949 when Westinghouse received U.S.P. 2,434,540 on tolyl xylyl and phenyl xylyl sulfones.

However, nothing commercial has materialized to date. Westinghouse continues to experiment and has long said that they may yet use xylyl tolyl sulfone as an additive

to Aroclor for a small specialized captive use. Monsanto makes the material on a very small scale to have it available for those who want some from time to time for experimental work.

1950 - This was the approximate time when Westinghouse was the first to commercially replace Aroclor 1254 with our Aroclor 1242.

G. E., who had also explored Aroclor 1242, was afraid of it. They said, "Either they are wrong or Westinghouse is headed for a great deal of trouble."

However, economic pressure and better low-temperature requirements forced G. E. to learn how to handle the much more "touchy" Aroclor 1242. Then in 1952 they switched. Eventually, this forced the entire industry to adapt Aroclor 1242. The transition is now about completed.

1951 - IN-420, dichloroalpha methyl-styrene dimer: This was developed by the Federal Telecommunications Laboratory and heralded as a total replacement for Aroclor. The properties of this product are very similar to those of Aroclor 1254. However, IN-420 was claimed and proved to give longer DC life than possible with Aroclor (actually no one was really complaining about the DC life of the Aroclor units).

Not knowing the possible impact of this development coming before Aroclor 1242 had chance for firm market establishment - Monsanto bought exclusive rights to IN-420 for $10,000 (the initial look-see). Our process costs dictated that the best sale price was about 70 cents a pound, at a one-million-pound minimum.

Our serious effort at sales promotion (at this unfavorable economic level) resulted in only an order for four drums by a small capacitor maker interested merely because it was a new and different dielectric. The industry turned down IN-420 because it was not worth one cent a pound more to them than Aroclor 1254, selling around 15 cents. This was a good exercise to experience the importance of economics in the capacitor business.

1955 - In 1952, U.S.P. 2,585,947 and in 1953 U.S.P. 2,662,995 issued to Dr. J. E. Lilienfeld covering use of an electrolytic type condenser for alternating current power circuits.

This development created much interest and several capacitor makers including some of our customers, i.e., G. E. and Aerovox, invested up to $100,000 for a license. They

keenly felt need to protect their positions, if finally now an electrolytic unit was destined to challenge the exclusive use of fixed-paper - Aroclor-impregnated capacitors for the fast growing power market.

While quite a surprise to everyone, the fact was that this revised electrolytic unit worked, indeed for AC applications. The liquid used consisted mainly of phenol with some toluene and a portion of sulfuric acid. The anticipated market was the newly booming air conditioner field which was greatly helping to increase sale of our Aroclor. But who wants to have a can of phenol, toluene and sulfuric acid blow up in the living room air conditioner?

Accordingly, this new electrolytic called the Ensar Power Capacitor failed to accomplish commercial use. On the other hand, the doctor and his sales promotion man, Mr. Powers (the nomenclature here is purely a coincidence) collected ample sums from this development, when needed to continue their fond pleasure of sailing the South Pacific waters in their small boat.

1959 - G. E. got real interested in dichlorobiphenyl oxide which could be obtained from Dow. This good dielectric has a DK of 10, considerably higher than the value for Aroclor 1242, and it also has slightly better low-temperature properties than our material. Unquestionably, an indicated sale price of somewhat over 40 cents a pound and doubts about availability from the Dow process are the factors keeping this material from competing with Aroclor 1242 readily available at much lower cost.

As further evidence of G. E.'s strong interest, they induced us to prepare a small amount of 2,2' dichlorobiphenyl ether from orthophenyl phenol, orthonitrochlorobenzene and chlorine. Monsanto is well-known to have all three of these raw materials. Cost of this good product continues to preclude it from competing with Aroclor 1242.

1961 - For many years G. E. entertained the idea of eliminating some of the less desirable isomers of the highly complex chlorinated biphenyl mixture. Fortunately, their approach was awkward as starting with finished Aroclor 1242 they had to go backwards to remove components. While cooling at low temperature was simple enough to remove undesired 4,4' dichlorobiphenyl, a tub full of Aroclor was required for feeding laborious fractional distillations to get a trickle of some desired trichloro isomer possessing the sought higher DK values.

G. E. gave up on this to put their efforts into new VPC analytical techniques to thoroughly study the nature of the Aroclor isomeric complex.

Fearing competition as a result of the 1956 trouble, Monsanto assigned the funds needed to explore possibility of a relatively direct approach to enrichment of the desired isomer content of Aroclor 1242.

This resulted in our high DK Aroclor. However, market acceptance has not been gained because the cold, hard economics of capacitor construction revealed that the use of the new material would result in higher costs than those in vogue with Aroclor 1242.

Things of known interest but not mentioned previously because they never got to commercial consideration include:

1. Esters containing fluoro-methyl groups, patented by Sprague.

2. Tetrachloronitrobiphenyl: Monsanto made this very high, 25 to 30 DK, material in experimental amount for G. E.

3. Other items explored by Monsanto worthy of mention are ethyl orthonitrobenzenes and various nitriles.

4. Cyanoethyl sucrose is another high dielectric constant material patented as an additive for Aroclor.

For many years, Monsanto maintained very modest laboratory facilities where hundreds of possible dielectric candidates were screened in a strictly preliminary way. Things that appeared of possible interest were submitted mainly to G.E. for further testing. Nothing fruitful evolved, and in recent years Monsanto has not carried on with such effort. G.E. also gave up further effort to directly alter or improve the properties of Aroclor and for that matter any other halogenated aromatic dielectric materials. Logically, they concluded that we are best able to do this kind of thing.

1962 to 1966

Instead around 1962 G.E. dedicated their research efforts to finding an additive or partial replacement for Aroclor, or in fact to develop an entirely different capacitor system.

Late in 1965, G.E. announced Pyranol 2 ballast and motor run capacitors. This fluid is Aroclor 1242 containing about 0.25% of a diepoxide stabilizer, believed to be Carbide's Unox 206 or Unox 269 disclosed in G.E.'s British Patent 986,950 and G.E.'s March 1966 USP 3,242,401 and 3,242,402. Use of these hydrogen chloride scavengers is primarily an expedient to

justify maintaining the smaller harder working capacitor designs developed over the past five years.

Then early in 1966 General Electric announced their Slimvar 400 and their Magnovar 150 KVAR power capacitors. These use a plastic film as partial replacement for the normally used Kraft tissue paper insulation. The very high electrical stress accommodated by the plastic film allows building a much smaller capacitor. Indeed this is the first time that more than 100 KVAR's have been packed into one can. Thus far, this plastic film - paper - Aroclor 1242 capacitor system has been introduced only for power capacitors. Pending further developments, it may be of interest for motor-run, large ballast and energy storage capacitors.

APPENDIX B

THE MARKETS FOR AROCLOR CAPACITORS

Power Factor Correction (AC)

All utilities and many industries strive for maximum line loss factor correction, accomplished by installing large 50 to 100 KVAR, AC, capacitors. This approach, which gains maximum utilization of electric power, is far more economical than an equivalent increase of generating capacity.

While demand for Aroclor capacitors has markedly increased for this purpose and the future is very strong - paradoxically Aroclor has not fully shared this growth.

Power line correction had been a 35 million dollar market in the early 1950's. Today, with far more capacitors employed, this annual market is valued at only about 18 million dollars. Particularly after 1956, dependability on the stability quality of Aroclor and significant improvements in the quality of the Kraft paper used, allowed capacitor designers to cut components (including Aroclor) roughly in half.

Thus, today a 100 KVAR unit is about the same size as was a 50 KVAR capacitor six years ago; and it does twice the work. Hard pressed by competitive cost-price squeezes, the capacitor makers fully employ such smaller designs to accomplish price cuts. Thus, a 50 KVAR unit priced around $165 several years ago, now sells for only $89. Under these circumstances - we as well as our customers are suffering commercially from an advancing technology in design. With our relatively constant Aroclor pricing, we have been on a volume and earnings plateau in a fast growing market.

However, no one of right mind would be inclined to invest further in design "brinkmanship," lest these units come nowhere near meeting the expected 25 to 30 years of life.

Therefore, it was to be expected that Aroclor would begin to more fully share the great growth predicted for power capacitors. This would certainly hold true in terms of the standard type capacitor designs.

However, now that G.E. has introduced a much different design using plastic film and less Aroclor and paper, the situation will be qualified by the commercial success of G.E.'s new Slimvar 400 capacitor. It will be about two years before this becomes established. Then at the most it may cut down the Aroclor capacitor requirement by 25 per cent from what it would have been otherwise. In turn, this reduction will be counter-balanced through increased use of capacitors.

Air Conditioner Units (AC)

No one is allowed to market an air conditioner without a built-in motor running capacitor. Aroclor units are used exclusively for this purpose of getting the most effective use of the available power. Thus, as our population grows and we strive to live more comfortably, the demand for Aroclor air conditioner capacitors will increase. Late in 1966, G.E. will have marketed Pyranol 2 type Aroclor capacitors for air conditioners. As yet, possible use of the Aroclor - plastic film - paper system for this purpose has not been clarified.

Fluorescent Lighting (AC)

Aroclor capacitors are standard for all fluorescent lighting ballasts. Formerly used only indoors, a great deal of fluorescent lighting is now designed for outdoors as well. As living quarters, commercial structures, factories, government and institutional structures and outdoor lighting facilities are built for better living and to meet population growth - so will the use of Aroclor fluorescent lighting capacitors increase in use.

Over recent years, the strong growth of lighting and air conditioner capacitors resulted in Aroclor's use for these applications drawing almost even with the volume demand for Aroclor in power correction units.

While G.E. through their Pyranol 2 design appear to adhere to the "miniturized" sizes, most others are reverting to larger size air conditioning capacitors and will make no further cuts in size of ballast units.

So far, G.E. have not licensed others (than Reguladores Automaticos in Mexico) to use the Pyranol 2 design. We seek to learn G.E.'s policy regards licensing Pyranol 2, not primarily relative to our domestic objectives, but mainly regards possible International advantages.

Energy Storage Capacitors (DC)

This market emcompasses a number of interesting highly technical applications, ranging from use of a single 50 KVAR unit to banks of 2,500 or more capable of releasing up to seven million joules within a microsecond into a confined magnetic field. This amounts to taking all the electric power capable of generation in this whole country, within the same time interval, and directing and dumping it into a very small area. Typical applications include:

a) The hot-shot wind tunnels to test supersonic aircraft and rocket components at air speeds ten times the speed of sound.

b) Electrospark explosion, under water, to create shock waves of sufficient force to shape difficult-to-form metals into intricate contours, within millionths of a second.

c) Nuclear particle accelerators for nuclear fusion research, i.e., cyclotrons, plasma, etc. All of this is controlled by the Government at Los Alamos.

Because their production lines for fixed paper capacitors are standardized on Aroclor, the capacitor makers prefer to fill requirements for high energy DC storage with banks of Aroclor units.

However, recent work done in England indicates that castor oil units may give over twice as many shot-firings as possible with Aroclor units. Accordingly, castor oil is being resurrected and may replace some Aroclor where the application requires longer capacitor life.

Actually, castor oil is less stable than Aroclor, but its products of decomposition are not as offensive as are the halogen ions given off with slight breakdown of Aroclor. Efforts to stabilize the Aroclor have not been effective.

While capacitor demand for high energy storage is not expected to show any substantial growth, in any event it appears that Aroclor may encounter competition from castor oil in this area.

High Voltage Power Supplies (DC)

Aroclor fixed paper capacitors are used almost exclusively to meet the needs of this interesting market area possessing growth potential readily recognizable from the nature of the specific applications, including the following:

a) DC power supply filters

1) X-ray equipment
2) Electronic transmitters, radar, microwave, etc.
3) Any electronic or industrial direct current power supply requiring filtering for silicon rectifiers. This is the power supply approach taken in place of motor generators.

b) Intermittent duty pulse forming systems

1) Small surge generators
2) Linear accelerators, i.e., the Laser method for highly oriented light.

c) Flash tube light sources, i.e., flash photography

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d) High intensity directional light systems to guide aircraft in runway landings (this is not the conventional runway lighting).

e) Capacitor discharge welding systems

The above applications may be classified as DC light duty energy storage capacitors. In these areas, Aroclor will probably continue in exclusive use for these interesting growth markets.

APPENDIX C

COMPETITION

1. Historical Background

Monsanto's basic patents expired around 1950. Our historically sound pricing policies and the unbelievable respect held not only by G.E. but the entire industry regards our technical competence, are the two major forces that have continued to turn back potential competitors. Our reputation was temporarily damaged in 1956, but full confidence in Monsanto has again been restored.

Various technical attempts to compete with Aroclor in the past are discussed in Appendix A.

2. Potential Competitors Today

Only those with strong chlorine positions appear as logical contenders. The leading positions in this area are:

Dow
Columbia-Southern
Diamond Alkali
Solvay
Hooker
Olin Mathieson
Wyandotte

Today late in 1963 we know that:

a. Stauffer and Halowax Division of Koppers have been calling on the electrical industry to ask, "What do they have to do to get into the Aroclor business?" The industry reply has been, "Go back home, determine what you can offer us so that we can evaluate it."

b. Dow has contacted industry leaders regards "Aroclor-like" materials. This implies chlorinated biphenyl ethers. As far back as 1948, trichlorobiphenyl ether was recognized as a very good capacitor dielectric with slightly better low temperature properties than Aroclor 1242. However, priced around 40 cents a pound it could not compete with Aroclor.

Recent quotes from Dow indicate chlorinated polyphenyl ethers in the 25 to 28 cent a pound range, with possibility that the trichloro-compound might be available at a slightly lower level. As the directly chlorinated isomeric mix has about the same dielectric constant as Aroclor 1242, there is no economic advantage in using it unless the price is as low or lower than that of Aroclor 1242 (approximately 14¢/lb.).

Any time Dow's material is available in sufficient amount and priced with slight advantage over Aroclor - there is little doubt but that the industry would show real interest.

c. "Look-see" evaluation continues on cyanoethyl sucrose, offered by Eastman Kodak, as a high DK (12) additive for capacitor Aroclor. The material is reported to have good thermal and chemical stability, but it is too viscous even at 120°C. for normal impregnation techniques.

3. How Would Competitors Enter

a. It is generally felt that entrance would not be through the electrical but via the non-electrical markets. Here the general price structure is higher, the use conditions are generally less critical, but the markets and end uses are highly diversified.

b. Dow could look at the situation far more broadly. They are very strong in chlorine and have produced biphenyl for many years. Their costs are probably just as good as Monsanto's. They have a good position in hydroxy polyphenyls, but have never produced chlorinated polyphenyls. We assume that the size of the market, our pricing policies and our technical position have kept them out.

The key is chlorine and the availability of by-product biphenyl. If by-product biphenyl can be economically purified and upgraded such that it can be used to produce the very high quality electrical grade Aroclor, then low cost chlorine becomes a key factor. Whether it be Dow or anyone else, in the event of having large chlorine excess on hand, they would certainly consider chlorinated polyphenyls as a route to upgrade.

From time to time the Manufacturing Dept. has made an analysis of Aroclor costs for potential competitors based on certain assumptions regarding chlorine and biphenyl costs. The most recent analysis (June 1963) prepared by Mr. D. B. Hosmer is shown on page C-5.

This analysis clearly shows that at 18,000,000 pounds per year (approximately half of the total capturable Aroclor market) it is possible for some company with cheap chlorine to compete in the Aroclor market. However, to establish a real long-term position, such a company would need to produce biphenyl or else find a way to upgrade and utilize by-product biphenyl. In addition, he must have outlets for terphenyl and recovered muriatic acid. These technical problems, together with the marketing organization required to serve the widely diversified markets for Aroclor in competition with Monsanto's products and prices, have obviously discouraged competition.

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Are we likely to have a competitor in electrical Aroclor in the future? We think not unless there is an unusual growth in the market or he enters the field to supply other uses and then tries to sell the electrical grade products. Our reasons are as follows:

1) G.E. knows the economic foundation of our price structure as well as we do - they set the pattern. We have followed this, not violated it; and G.E.'s only regret is that they did not do the same in conducting their business because if they had done so, they would not have the fierce competition and poor profits they now have. Westinghouse and the rest who know about and understand our pricing policy have equal respect for it. The people who know this situation realize that if this business were divided, there would very likely be an increase in the price of Aroclor.

2) Assuming that we do not have G.E. or any other manufacturer cause to seek another source of Aroclor, any competitor would have to enter the market and attempt to take our business. We feel that he would have a very difficult job on his hands. Monsanto's experience in making a quality product, production, handling, shipping and analytical know-how, plus our excellent reputation for technical service and prompt delivery, has built a very good relationship with the capacitor manufacturers. We have no reason to believe that many of our customers would offer a split of his business to any new, unproved supplier.

4. Overseas

Chlorinated biphenyl is produced overseas as follows:

England	MCL
France	Progil
Germany	Bayer
Italy	Kaffaro
Japan	Kanegafuchi
Russia	Sovanol

These companies have never sold any chlorinated biphenyl in the U.S.A., and we do not expect them to do so in the future. The reasons for this are as follows:

a. Because of production capacity alone, we believe that nobody makes chlorinated biphenyl any cheaper than Monsanto. Since our quality and service are satisfactory, these foreign producers could only enter the market with a lower price.

b. The U. S. tariff on chlorinated biphenyl is 3.5¢/lb. plus 25% or the domestic market price (25% of 15¢/lb. or 3.75¢/lb.). Thus, the total tariff is 7.25¢/lb. Under these conditions, a foreign competitor would have to sell at or below our costs in drums on an f.o.b. basis. Present estimates by our tariff experts are that the tariff will not fall below 3.5 - 4.0 cents during the next five years. Considering freight, even at these reduced tariffs, overseas producers cannot compete effectively in the U.S. market.

c. Because of the many technical and quality problems with Aroclor in capacitors, none of the major capacitor manufacturers would trust overseas production with a major testing program. They would need a powerful incentive to do this, and we don't believe that such is possible. Thus, we are not concerned about competition from foreign producers.

d. However, as it has been established that our Aroclor quality is not as good as material from Bayer and Prodelec - Monsanto needs make all-out effort to improve our quality.

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Monsanto

FROM (NAME & LOCATION) St. Louis - General Office

C-5

DATE : June 6, 1963

CC: H. L. Minckler - HMINC

SUBJECT : AROCLOR - BULK MANUFACTURING COSTS

REFERENCE : DBH to RON dated 2-7-61
JOB to RSW dated 3-1-61

TO : Mr. R. S. Wobus - RWOBU

As a result of our recent discussion, I have estimated Aroclor manufacturing costs that might be attained by a potential competitor who decided to make this line of products. For purposes of the comparison raw material usages for Aroclor 1248 were assumed since they represent pretty well an average of our product mix at Anniston.

Chart No. I is attached which shows bulk manufacturing costs for various cases. It is believed that the chart is self-explanatory but some comments concerning the results may be of interest.

It would be very attractive at current plasticizer Aroclor prices for a competitor to enter the market if he could attain an 18$\overline{M}$ lb. annual volume even though he was required to purchase both biphenyl and chlorine. 18$\overline{M}$ lbs. x (0.1525 - 0.12) = 585\overline{M}$ gross profit, with an investment of about 1\overline{M}$.

If either chlorine or biphenyl is made by a competitor the production of Aroclor for plasticizers is extremely attractive.

A strong competitor who might make both biphenyl and chlorine is overlooking a very profitable opportunity if he fails to enter the Aroclor business.

D. B. Hosmer

/dg
Attachment

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IN-10 REV. 11-65

CHART No. I

AROCLOR COSTS FOR POTENTIAL COMPETITORS AT 18M lbs/yr
Vs. Anniston Actual

Case No.	1	2	3	4	5	6	7
Chlorine	Purch. @ $50/T	Purch. @ $65/T	Purch. @ $50/T	Mftr. @ $35/T	Mftr. @ $35/T	Mftr. @ $40/T	Mftr. & Purch. @ $48.92/T
Biphenyl	Purch. @ $0.13/#	Purch. @ $0.17/#	Mftr. @ $ .0685/#+	Purch. @ $0.13/#	Mftr. @ $ .0685/#	Mftr. @ $ .0685/#	Mftr. @ $ .0601/# Anniston Actual 1st Quarter 1963
Manufacturing Cost							
Raw Materials:							
Chlorine @ 103.3#/cwt.	2.58	3.36	2.58	1.81	1.81	2.07	2.50
Biphenyl @ 56.5#/cwt.	7.35	9.60	3.86	7.35	3.86	3.86	3.41
Others	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Gross Raw Materials	9.94	12.97	6.45	9.17	5.68	5.94	5.92
Credit Hcl (28.9# @ $ .01625)	0.47	0.47	0.47	0.47	0.47	0.47	0.62
Net Raw Materials	9.47	12.50	5.98	8.70	5.21	5.47	5.30
Total Conversion	1.94	1.94	1.94	1.94	1.94	1.94	1.26
Bulk Mfg. Cost*	$11.41	$14.44	$7.92	$10.64	$7.15	$7.41	$6.56

*All bulk manufacturing costs assume that the competitor can sell 54.5% of the theoretically recoverable Muriatic Acid and credits himself at $0.01625/# which is essentially a net sales realization value.

+Biphenyl manufacturing costs assume that the competitor has an outlet for Terphenyl and credits himself at Benzene value for this by-product.

With no by-product Hcl credit and no outlet for Terphenyl (Santowax at no value) Aroclor costs in Cases 3, 5 and 6 will increase by $0.82/cwt.

With no by-product Hcl credit Aroclor costs for Cases 1, 2 and 4 will increase by $0.47/cwt.

DEFINITION OF CASES

Case No. 1 and 2 - Represents cost parameters for a competitor who would purchase both biphenyl and chlorine.

Case No. 3 and 4 - Represents a competitor who would purchase either chlorine or biphenyl but not both.

Case No. 5 and 6 - Characterizes the parameters for a strong competitor who makes both biphenyl and chlorine.

Case No. 7 - Anniston actual first quarter of 1963.

Cl_2 = 102.158#/cwt.
Biphenyl = 56.674#/cwt.

Capital requirements for the various cases are shown in reference memo #21.

APPENDIX D

DETAILS OF PRICING STRATEGY

ELECTRICAL GRADE AROCLOR

A. Pricing History

Seeking the lowest possible sales price under conditions acceptable to Monsanto, G.E. contracted in the late 1930's for Aroclor to be priced according to the following formula. Since G.E. was our most important customer, this formula was used to establish the price of Aroclor.

Base price - $10.39 cwt. figuring chlorine at $40/ton and benzene 17¢/gal.

Escalation based on:

$0.10 cwt. for each 1¢ per gallon change in price of benzene

$1.20 cwt. for each 1¢ per pound change in price of chlorine

Note: The attached Table I shows actual changes in Aroclor prices, prices that would have been charged under the above formula and reasons for pricing action over the past 15 - 20 years.

This original strategy accomplished the following goals:

1. To give Aroclor the best possible market acceptance in capacitors and transformers by providing the lowest possible price.

2. To provide Monsanto a justifiable and good long-term profitability required to function as a reliable supplier.

After expiration of Monsanto's basic patents around 1948, Monsanto continued to adhere to the contract formula strategy until:

February 5, 1954, when:

a. Aroclor transferred from Inorganic to the Organic Division.

b. The price of benzene was at all-time high.

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Now for the first time, Monsanto allowed Aroclor to sell under the contract formula price and by 5/15/56 the price was $0.86 cwt. below the contract. Obviously, G.E. did not insist that we adhere to the contract.

While G.E. recognized these reductions as filling Monsanto's goals, they were not impressed because this in no way satisfied their goal for advantage over their competitors.

Thus, G.E. through the Hudson Falls Capacitor Department continued to seek a volume price reduction for the following reasons:

1. They are by far the largest volume purchaser.

2. They do most the research and development by which all others benefit (for free).

3. Except for Aroclor, they buy their materials on a volume - price basis. They sell their goods on this basis.

4. If they gave their Aroclor requirements to someone else, they feel our costs would increase.

Monsanto remained firm in not giving a volume-price because:

1. We could not account for enough savings in this particular business to arrive at a worthwhile and yet legal volume-reduction.

2. Fear that granting a volume-price on Aroclor would spill over into other chemical areas to create broader problems.

3. Apprehension that our other customers (all much smaller than G.E.) would be provoked.

This volume-price refusal was the only reason G.E. had for not being completely satisfied with Monsanto. Actually they respected our stand. However, several times the discussions became rather heated and emotions ran high.

On January 2, 1957, Monsanto raised the price of Aroclor $0.45 cwt. but absorbed freight (FOB-freight allowed). This action did two things:

1. The price to Hudson Falls was now $1.96 cwt. below the G.E. contract arrangement (considering freight).

2. G.E. was especially satisfied. This freight absorption represented a considerable savings to G.E. They had the most costly freight haul and bought by far the most material.

By early 1958 it was clear that G.E. was badly hurt (probably around 8 million dollar loss) due to capacitor failures made with Anniston's mid-1956 production of Aroclor. G.E. was clearly very unhappy with Monsanto, and cancelled the contract based on chlorine and benzene escalation. Top G.E. management solicited most all leading and small chemical makers to determine whether another Aroclor supplier could be established. Some companies supplied acceptable quality samples. None could compete with our price.

In June of 1958 Monsanto acted to help G.E. in their problem of financial losses due to capacitor failures with Aroclor. This action consisted of:

1. Raise price of Aroclor $0.50 cwt. across the board.

2. Grant G.E. $1.50 cwt. credit on all Aroclor purchased until $1,000,000 credit has been reached - probably by January 1967.

This action cost Monsanto very little and greatly improved over-all relations with G.E.

A similar arrangement was made with Westinghouse to cover a maximum credit of $250,000 (terminated in 1961).

As shown by Table I, all subsequent price changes have been due to routine factors involving raw materials and freight. It should be noted that in March 1962, the price of Aroclor was $0.13 cwt. above what would be allowed by the G.E. contract had it still been effective.

On March 29, 1962, the Aroclor sale price was lowered $0.28 cwt. bringing it $0.15 cwt. below what would be allowed if the G.E. contract were active. This action was taken to reflect the lower prices for benzene.

Today the electrical grade Aroclor price schedule is essentially where it was in the early 1940's. This is in relation to the cost of the raw materials, chlorine, benzene and freight. Accordingly, Monsanto retains the good long-term profitability.

However, we can expect other companies to continue to look at chlorinated biphenyls. Recently, Stauffer and Koppers visited Westinghouse to see what they can do about getting into this business. Such probing which has gone on for years will grow more earnest as the chemical price squeeze intensifies.

B. Factors Affecting Future Pricing

1. Aroclors in the capacitor industry do not represent an exceptional growth market - estimated at 25 - 30% over next 5 years (see Table I).

2. Our studies and judgment indicate that the demand for Aroclor capacitors is not sensitive to small changes in Aroclor price - up or down. For example, increasing the price of Aroclor up to 25% would have little or no effect on total sales.

3. Aroclor is a highly profitable product and prices could be reduced if necessary.

4. We can always expect the threat of competition. Product quality and service are our best insurance against competition.

5. Chlorinated biphenyl is produced in Europe, but we do not expect foreign production to compete in American markets (see Appendix C).

6. As long as we can supply the business at G.E. and Westinghouse, it will be difficult for competition to enter the electrical field with Aroclor. They account for approximately 55% of our electrical business.

7. Aroclor prices have historically followed the prices of benzene and chlorine - the major raw materials.

8. Prudent marketing decisions to the electrical industry and their effect on possible competition will lose their value unless comparable careful consideration is given the marketing of Aroclor for other applications (plasticizers, fluids, etc.). Competition can enter most easily through such non-electrical applications.

C. Monsanto Pricing Strategy

1. On Our Own Initiative

a. We anticipate no price change in Aroclor used in capacitors unless there are changes in raw materials or freight.

b. We will change Aroclor prices if price change in chlorine, benzene and freight total $0.20 cwt. change in Aroclor.

c. The new agreement with G.E. does not expire until 1972-73. Because of their large volume purchases, they represent the most important target for any potential competitor. Thus, we must always consider some approach under which we can do something "special" for G.E. in order to keep them close to Monsanto.

d. If we are successful in establishing high concentrations of Aroclor 1242 for use in transformer blends, the price of Aroclor 1242 for transformer applications must be reduced below that presently charged for capacitors. We do not intend to lower the price for capacitor use to meet the price established for transformers.

AROCLOR - ANNISTON, ALABAMA
PRICING

TABLE I

AROCLOR PRICE CHANGES BY G. E. CO. CONTRACT
AROCLOR BASE PRICE = $10.39/100 LBS. F.O.B.

0.1 CENT PER POUND AROCLOR FOR EACH 1.0 CENT PER GALLON BENZENE
1.2 CENTS PER POUND AROCLOR FOR EACH 1.0 CENT PER POUND CHLORINE

YEAR	AROCLOR SALES PRICE PER 100 POUNDS	G. E. CONTRACT PRICE PER 100 POUNDS	SAVINGS TO G. E. PER 100 POUNDS	TOT. DELIVERED BENZENE PRICE PER GAL.	COLUMBIA SOUTHERN DELIVERED CHLORINE PRICE PER TON			FREIGHT INCL. TAX ANNISTON TO HUD. FALLS, N. Y. PER 100 LBS.	COMMENTS
BASE	$10.39 F.O.B.	$10.39 F.O.B.	$0.00	$0.17 (+ FRT.)	$40.00 +	FRT.	TOTAL		
1944	12.50 "	12.50 "	0.00	0.17 "	35.00 "				
1945	12.50 "	12.50 "	0.00	0.17 "	35.00 "				
10/1/1946	10.00 "	10.00 "	0.00	0.17 "	36.75 "				
10/1/1947	10.50 "	10.50 "	0.00	0.19 "	45.00 "				
7/1/1948	11.20 "	11.20 "	0.00	0.20 "	48.00 "				
1949	11.46 "	11.46 "	0.00	0.20 "	48.00 "				
1/1/1950	11.34 "	11.34 "	0.00	0.2275	48.00 "				
2/1/1950	11.54 "	11.54 "	0.00	0.2375	48.00 "				
9/14/1950	12.70 "	12.70 "	0.00	0.3175	54.00 "				
9/4/1951	13.15 "	13.15 "	0.00	0.4175	54.00 "				
11/20/1952	13.15 "	13.15 "	0.00	0.4175	54.00 "				
6/20/1953	14.00 "	14.00 "	0.00	0.4200	58.60 "				
							TOTAL		
2/5/1954	14.00 "	14.50 "	0.50	0.4678	58.60	$12.60	$71.20		G. E. COMPANY CONTRACT PRICING NOT FOLLOWED. MONSANTO'S ORGANIC DIVISION BEGAN LOWER PRICING.
10/1/1955	14.00 "	14.19 "	0.19	0.3700	61.00	10.66	71.66	$1.3184	BENZENE DROPPED 9.78¢/GAL., CHLORINE INCREASED $2.40/TON, FRT. DROPPED $1.94/TON ON CL.
*5/15/1956	13.43 "	14.29 "	0.86	0.3700	61.00	10.66	71.66	1.4008	MONSANTO LOWERED AROCLOR SALE PRICE $0.57 PER 100 LBS.
*1/2/1957	13.88 DELIVERED	14.37 "	1.96	0.366	63.00	10.66	73.66	1.4729	MONSANTO ABSORBED FREIGHT TO HUDSON FALLS, N. Y. AND RAISED AROCLOR PRICE $0.45 PER 100 LBS.
9/4/1957	13.96 "	14.38 "	1.96	0.3675	63.00	10.71	73.71	1.5244	5 PERCENT FREIGHT INCREASE.
3/24/1958	13.96 "	14.51 "	2.09	0.3675	63.00	12.77	75.77	1.5450	FREIGHT INCREASE. G. E. CANCELLED THE CONTRACT LATE IN 1957.
*6/6/1958	14.46 "	14.51 "	1.60	0.3675	63.00	12.77	75.77	1.5450	MONSANTO RAISED PRICE $0.50 PER 100 LBS., ISSUED CREDIT TO G. E. OF $1.50 PER 100 LBS.
8/1/1958	14.46 "	13.98 "	1.02	0.3166	63.00	12.40	75.40	1.5000	3 PERCENT FREIGHT REDUCTION AND 5 CENTS PER GAL. BENZENE REDUCTION.
1/1/1960	14.98 "	14.29 "	0.81	0.3466	63.00	12.60	75.60	1.5000	BENZENE INCREASED 3 CENTS PER GAL. ON 10/12/1959.
2/17/1960									FREIGHT REDUCED FROM 9½ TO 8 CENTS PER 100 LBS. ON BENZENE FROM ALABAMA CITY.
4/1/1960	14.98 "	14.412 "	0.93	0.3466	65.00	12.60	77.60	1.5000	CHLORINE INCREASED $2.00 PER TON.
5/15/1961	14.98 "	14.412 "	0.93	0.3466	65.00	12.60	77.60	1.5000	CHLORINE FRT. INCREASED 1¢/100 ON RATE ABOVE 65¢/100 AND ½¢ ON RATE UP TO 65¢/100 LBS.
7/15/1961	14.98 "	14.112 "	0.632	0.3166	65.00	12.60	77.60	1.5000	BENZENE LOWERED 3 CENTS PER GAL., MONSANTO DROPPED PLASTICIZER AROCLOR 1¢ LB.
9/10/1961	14.98 "	13.95 "	0.47	0.3166	65.00	9.90	74.90	1.5000	9/10/61 CHLORINE FREIGHT REDUCED FROM $12.60/TON TO $9.90/TON FROM HUNTSVILLE, ALA.
2/1/1962	14.98 "	13.65 "	0.17	0.2866	65.00	9.90	74.90	1.5000	2/1/62 BENZENE LOWERED 3¢/GAL. TO 28¢., MONSANTO DID NOT CHANGE AROCLOR PRICE.
3/20/1962	14.98 "	13.35 "	Loss - 0.13	0.2566	65.00	9.90	74.90	1.5000	3/20/62 BENZENE LOWERED 3¢/GAL. TO 25¢., MONSANTO DID NOT CHANGE AROCLOR PRICE.
3/29/1962	14.70 "	13.35 "	0.15	0.2566	65.00	9.90	74.90	1.5000	3/29/62 MONSANTO LOWERED AROCLOR $0.0028/LB.
4/22/1963	14.70 "	13.338 "	0.14	0.2566	65.00	9.70	74.70	1.5000	4/22/63 OLIN'S NEW PLANT CHARLESTON, TENN. FRT. 4/28/62 QUOTED $9.70/TON CHLORINE INSTEAD OF $9.90 WE HAD USED FROM HUNTSVILLE, A.A., ALTHOUGH HUNTSVILLE IS NEARER ANNISTON.
7/8/1963	--	--	--	--	--	--	--	--	7/8/63 AROCLOR 1260 CHANGED TO $13.70 CWT. AND FOB OUR FACTORIES.
1/22/1964	14.50 "	13.338 "	0.338	0.2566	65.00	9.70	74.70	1.2300	10/15/63 FREIGHT REDUCED ON 90,000 LBS. OUR RATE BECAME $1.27 CWT. ON 1/22/64 PRICE LOWERED 0.20¢/LB., BULK ONLY RE: 10/15/63 FREIGHT REDUCTION

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