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AROCLOR PLASTICIZER WITHDRAWAL PLAN

A guide to assist the Field Sales Force in carrying out the Aroclor Plasticizer Withdrawal Program

Contents

1. Objectives
2. Specific actions which will occur
3. Planned support from St. Louis
4. Products to be withdrawn
5. Key customer list
6. The notification letter for all customers
7. The rationale for withdrawal
8. A list of Dos/Don'ts
9. The list of replacement products

W. S. Clark
12/7/71

MONS 043545

Objectives of Aroclor Plasticizer Withdrawal Program

1. Terminate sales of Aroclors as plasticizers by 3/31/71.

2. Carry out the withdrawal in such a way as to minimize customer ill will.

Specific Actions That Will Occur

1. Informal notification of key accounts - 12/21 to 12/31/71.

2. Formal notification of all Aroclor accounts by mail - 12/31/71.

3. Management visits to key accounts from 1/3/72 to 1/4/71. Earlier visits may be scheduled if necessary.

4. Shipment of normal quantities of material to customers from 1/1/72 to 3/31/72. "Normal quantities" will be defined relative to sales during the last six months of 1971.

5. No shipments will be made after 3/31/71.

Support From St. Louis

1. A listing of replacement products in as many application areas as is possible will be provided.

2. Business group management will call at selected key accounts as listed on a subsequent page.

3. There will be a very limited amount of application research time available for those accounts 1) where we have good background in the application area, 2) where the replacement potential is 300,000 pounds/year or more of Monsanto plasticizers, and 3) where prior approval has been obtained from the product group.

4. Technical visits by our research group will not be included in the withdrawal program.

Products to be Withdrawn

Product

Aroclors - all products

Montar 5

Santicizer 301

Santicizer 311

Santicizer 326

Santicizer 327

Santicizer 335

Santicizer 336

Santicizer 337

MXP 101

Key Accounts — To be called on by St. Louis Business Group personnel and appropriate Field Sales personnel.

1. Aroclor Sales Only -

   - Either the account is large enough to warrant a call (Valspar), or the use of Aroclor is sufficiently sensitive as to create an unusually large problem (Products Research).

1.	Products Research	Clark/Schalk
2.	Valspar	Clark/Schalk
3.	Chrysler	Clark/Schalk
4.	Yates Manufacturing	Clark/Schalk
5.	Swift	Clark/Schalk

   - The following accounts should be visited by the regional manager -

     1. Colonial Press
     2. Dreyfus

2. Major Plasticizer Sales Other Than Aroclor -

   - These accounts all represent continued sales in other product areas. The best possible communications must take place at the highest level feasible.

1.	National Starch	J. E. Springgate and A. W. M. Coaker
2.	H. B. Fuller	J. E. Springgate and A. W. M. Coaker
3.	Central Solvents	J. E. Springgate
4.	Amsco	J. E. Springgate
5.	3M Company	M. W. Farrar

MONS 043548

- The following accounts should be visited by the regional manager

  1. General Electric
  2. Inmont
  3. Nashua
  4. W. R. Grace
  5. Uniroyal
  6. United Resins
  7. Borden

3. Others -

- Monsanto should probably also call on Thiokol and Hercules as these companies have been major specifiers of Monsanto products (Aroclors).

1.	Thiokol	Morgan/Clark
2.	Hercules	Morgan/Clark

It should be noted that at any of the accounts where St. Louis personnel are listed, additional people may want to be involved with the call.

Monsanto

MONSANTO INDUSTRIAL CHEMICALS CO.
800 N. Lindbergh Boulevard
St. Louis, Missouri 63166
Phone: (314) 694-1000

December 31, 1971

Dear Sir:

We are writing to advise you that Monsanto has made the decision to cease the sale of polychlorinated terphenyls for use as plasticizers and for use in other open system applications effective March 31, 1972. These products have been sold by Monsanto under the trade name Aroclor®.

Normal volumes of our existing Aroclor product line may be purchased between now and March 31, 1972, however, no shipments will be made after that date. Sales during the last six months of 1971 will determine normal order quantities.

Monsanto is working to develop a list of suggested replacement products and suppliers to be used as a guide in replacing our Aroclor® products in existing formulations. This list may be obtained by contacting any of our regional offices whose addresses and telephone numbers are shown on the attached sheet.

Very truly yours,

W. E. Schalk
Sales Director
Plasticizers

/dbw

The Rationale for Withdrawal

When presenting the fact to the customer that Monsanto has made the decision to take Aroclors as plasticizers off the market, you should use the following statements wherever possible. Do not try to put together your own story. Stick to the statements below. If questions arise which cannot be answered from the information presented, refer the questions to Clark/Schalk/Springgate in that order.

Questions/Answers

1. Q. Why is Monsanto discontinuing these products?

   A. You have probably read a great deal in recent months about PCB. This is a chemical substance which, because of its persistent nature, has been found in several species of wildlife and has been considered by some people to be an environmental contaminant. Aroclor plasticizers are not PCBs, but are from the same chemical family. As a corporate citizen of this country, our concern for the environment has led us to stop all sales of PCB in the U. S. except for a limited number of confined, closed system applications and only when certain conditions are met. Since Aroclor plasticizers are of the same general family as PCBs, we feel our action in discontinuing the manufacturing and sale of these products is appropriate in order to prevent presently unknown but possible future problems.

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2. Q. Why didn't Monsanto have adequate information when they introduced terphenyl blends fifteen months ago?

   A. When terphenyl blends were introduced into the plasticizer market, Monsanto was acting on the best information available at the time. This is a period of rapidly advancing technology, particularly in the environmental area. Each month seems to bring new information and new developments. We will continue to make our decisions on the best available information.

3. Q. Is this a discontinuation to the _____ industry (e.g., adhesives) or is it an across the board discontinuation?

   A. This discontinuation is across the board applying to all Aroclor plasticizers.

4. Q. Can we (the customer) purchase these products if we certify that they will not get into the environment?

   A. The decision made by the Company is that all Aroclor plasticizers sales will be discontinued by March 31, 1972.

5. Q. What can we buy for inventory now?

   A. We are allowed to sell only such quantities as would be used prior to March 31. Sales during the last six months of 1971 will be used as a basis for computing allowed sales up to March 31, 1972.

6. Q. Can we buy these anywhere else?

   A. We know of no other U. S. marketer of Aroclor plasticizers.

7. Q. Whom can we contact in St. Louis?

A. W. S. Clark and W. E. Schalk.

If any other questions are asked, refer the customer to St. Louis, or just say, "I don't know".

DOS/DON'TS

RESEARCH WORK

DO

1. Replacement work on hot melts, polysulfide sealants, chlorinated rubber coatings prior to withdrawal notification. Publish work.

2. Selected application work requests provided -

   a. Pre-approval from product group is obtained.

   b. The potential is greater than 300,000 pounds/year of Monsanto products - see attached list.

   c. We have some background in the application area.

3. Generate a list of replacements for all applications based on experience and background.

DON'T DO

1. Replacement work outside of hot melts, polysulfides, chlorinated rubber.

2. Miscellaneous work requests from the Field.

3. Miscellaneous programs suggested by group leaders and market supervisors.

4. Make technical visits except as previously scheduled.

DOS/DON'TS

PRODUCT GROUP

DO

1. Notify Aroclor customers by mail - approved by Law Department.
2. Visit key accounts as per attached list.
3. Publish rationale behind Aroclor withdrawal.
4. Publish information to Field Sales by letter/ wire/personal visit on 12/21/71.
5. Get PR involved with some press releases.
6. Set up controls with COP and Distribution to limit sales to acceptable levels.

DON'T DO

1. Notify any customers prior to 12/21/71. Don't notify any customers direct.
2. Don't visit accounts other than those shown on attached key account list.

DOS/DON'TS

FIELD SALES FORCE

DO

1. Notify all Aroclor customers by telephone no later than 1/7/72.
2. Notify major Aroclor/Plasticizer customers as appropriate between 12/21/71 and 12/31/71.
3. Make arrangements for management visits at only the key accounts listed on pages 4 and 5.
4. Present replacement data.
5. Use published "Rationale" explaining our product withdrawal. See pages 7, 8, and 9.
6. Consider application lab work only for the accounts listed on the attachment.

DON'T DO

1. Don't schedule management visits other than those outlined.
2. Don't get into detailed, lengthy discussions on the rationale behind our withdrawal. Present it as fact. Don't try to defend it past what is in the party line statement. Don't try to discuss the legal aspects in any fashion. This is virgin territory without adequate precedence.
3. Don't commit to any application lab work.

Replacement Suggestions

The replacement product list has not yet been put together.

Accounts for which we will consider doing application work -

General Electric

3M

Inmont

Nashua

W. R. Grace

H. B. Fuller

National Starch

Uniroyal

General requests from other major companies if they fall into the following categories:

- Hot melt adhesives
- Chlorinated rubber coatings
- Polysulfide sealants

DRAFT

"This Report Is Not Meant To Be An Exhaustive Study. It Was Prepared In Response To A Specific Inquiry For Rapid Retrieval And Assembly Of Information"

MARKET INPUT/OUTPUT PROFILE, PROCESS TECHNOLOGY ASSESSMENT AND ENTRY INTO THE ENVIRONMENT OF POLYCHLORINATED BIPHENYLS (PCBs)

TASK ORDER NUMBER 1

PREPARED BY FOSTER D. SNELL, INC.
FOR UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
UNDER CONTRACT NUMBER 68-01-2106

DECEMBER 1973

MONS 043559

TABLE OF CONTENTS

		Page
SECTION I	FINDINGS AND CONCLUSIONS	I-1
SECTION II	RECOMMENDATIONS	II-1
SECTION III	INTRODUCTION	III-1
SECTION IV	PRODUCTION QUANTITIES	IV-1
EXHIBIT I	Composition of Different Liquid PCB Products	IV-11
EXHIBIT II	PCB Manufacture and Sales Monsanto Industrial Chemicals Co.	
EXHIBIT III	End-Used of Aroclors	
SECTION V	MANUFACTURING PROCESSES	V-1
EXHIBIT IV	Patent Digest	V-6
EXHIBIT V	Process Flow and Environmental Controls at Monsanto's Sauget Plant	
EXHIBIT VI	Shipping of Aroclor Plasticizers	
EXHIBIT VII	Example of Current Aroclor Labeling Practice	
EXHIBIT VIII	Excerpts From NEMA's Proposed Environmental Controls	
EXHIBIT IX	Disposal Services Listed in Section 4 of NEMA's Official Standards Proposal	

TABLE OF CONTENTS (continued)

		Page
SECTION VI	MANUFACTURING PROCESSES IN WHICH PCBs ARE USED	VI-1
EXHIBIT X	Historical Distribution of PCB Types and End-Use	VI-17
EXHIBIT XI	PCB Use in the Electrical Industry	
EXHIBIT XII	Transformer Trends (1967-1974)	
EXHIBIT XIII	Fluorescent Lamp Ballast Shipments (1963-1972)	
EXHIBIT XIV	PCB Losses in Capacitor Manufacture	
EXHIBIT XV	Transformer Imports	
EXHIBIT XVI	Excerpts From Broadhurst On PCB Technology in Open Systems and Heat Transfer	
EXHIBIT XVII	PCB Levels Associated With Various Products/Processes	
SECTION VII	THE ENTRY OF PCBs INTO THE ENVIRONMENT AND MANAGEMENT STEPS	VII-1
EXHIBIT XVIII	PCB Service Life Functions	VII-12
EXHIBIT XIX	Example of the Use of PCB Service Life Functions: Estimate of Capacitor PCBs In-Service	
EXHIBIT XX	Historical Pattern of PCB Channels To The Environment	
SECTION VIII	BIBLIOGRAPHY	VIII-1

MONS 043561

ABSTRACT

The Office of Toxic Substances of the United States Environmental Protection Agency issued a task order to Foster D. Snell, Inc. under Contract No. 68-01-2106 to prepare a broad report on a rapid response basis on the "Market Input/Output Profile, Process Technology Assessment And Entry Into The Environment Of Polychlorinated Biphenyls (PCBs)".

The study scope included literature review, patent analysis and strategic interviews.

The Monsanto Industrial Chemicals Company is the sole use producer of PCBs under the "Aroclor" trademark. Production capacity is about 48 million lbs. annually. Imports appear to constitute 2% or less of domestic usage.

In recent years the use of PCBs has been voluntarily confined by Monsanto, essentially completely to transformer and capacitor applications. Roughly 500 million lbs. of PCBs are currently in-service, over 95% in transformers and capacitors.

Recommendations include in-depth study of the market, technical and environmental aspects of PCB use in transformers and capacitors. PCB management steps recommended for further evaluation are: banning use of the commodity in non-electrical applications and the granting of exemptions case-by-case; formal sanctioning of the National Standard Guidelines For Handling and Disposal of Capacitor - And Transformer - Grade Askarels Containing Polychlorinated Biphenyls; establishment of an enforcement mechanism that also applies to import controls.

SECTION I

SECTION I

FINDINGS AND CONCLUSIONS

This section serves as an executive summary of principal findings and conclusions related to PCB market trends, technology and environmental control patterns and information gaps.

1. PCB PRODUCTS ARE MIXTURES OF VARIOUS HOMOLOGS OF CHLORINATED BIPHENYL

   (1) Contaminants And Impurities In The Product Are Determined By The Quality Of The Starting Materials And Process Conditions

   (2) The Unique Physical And Chemical Properties Of PCBs Have Made These Substances Technically Attractive In A Variety Of End Uses

   (3) PCBs Have Been In Commercial Use In The U.S. Since The 1920s

   (4) The Tetrachloro And Lower Chlorobiphenyls Appear Less Persistent In The Environment Than The Higher Chlorobiphenyls

2. THE MONSANTO INDUSTRIAL CHEMICALS COMPANY IS THE SOLE U.S. PRODUCER OF PCBs

3. MONSANTO'S CURRENT APPROXIMATE NAMEPLATE PRODUCTION CAPACITY IS 48 MILLION LBS. PCBs PER YEAR (36)

4. ANNUAL STATISTICS FOR U.S. PRODUCTION AND SALES OF AROCLORS SHOW MARKED DECREASE CAUSED BY RESTRICTION OF USE TO ELECTRICAL APPLICATIONS SINCE 1971

   (1) Monsanto No Longer Sells PCBs For End-Uses Other Than Capacitor And Transformer Insulating Liquids

   (2) Domestic Sales Of Aroclors Are Expected To Increase At An Average Annual Rate Of 7.4% Over The Next Five Years

MONS 043564

5. THE PATTERN OF WORLD COMMERCE IN PCBs INDICATES LOWER FUTURE PRODUCTION AND RESTRICTED USAGE

(1) Import Statistics Indicate That Only About 2% Of PCBs Sold In The U.S. Were Imported In 1971 And About 1.4% In 1972

(2) Imports of PCBs Are Expected To Be Less Than 2% Of Total U.S. Sales During The Next Five Years

(3) During The Period From 1963 Through 1972 Exports Of Aroclors Were 78.7 Million Lbs.

(4) Exports of Aroclors Are Expected To Maintain The Same Ratio To U.S. Sales As In The Past Several Years (36), Or 10-15%

(5) Known Foreign Producers of PCBs Include Czechoslovakia France, Germany, Italy, Japan, Spain, and the U.S.S.R.

(6) World Commerce In PCBs Is Expected To Decrease By About The Same Amount Or More Than In The U.S. Since 1970, And To Be Essentially Confined To Capacitor And Transformer Applications

6. THE MANUFACTURE OF PCBs IS NOT A COMPLEX PROCESS

(1) Currently There Is Only One Known Commercial Scale PCB Production Installation In The U.S., Operated By Monsanto

(2) Monsanto Has Reported Significant Environmental Controls At This Plant

7. HISTORICALLY, AROCLORS HAVE BEEN SHIPPED IN A FASHION SIMILAR TO ANY OTHER COMMODITY

Both Monsanto and the National Electrical Manufacturers Association (NEMA) have taken special steps toward environmental controls in future transport of PCBs.

8. THERE IS EVIDENCE OF RESEARCH AND DEVELOPMENT ACTIVITY TO CONTROL SPENT PCBs

Envirotech Corporation reported an energy saving method of combusting waste PCBs. In Japan chemical destruction methods have been studied.

9. DURING THE PERIOD FROM 1957 THROUGH 1973 (PROJECTED), ACCUMULATED U.S. CONSUMPTION OF PCBs WAS ABOUT 775 MILLION LBs., INCLUDING IMPORTS

(1) During The Period From 1957 Through 1973 Approximately 234 Million Lbs. Of PCBs Were Used In "Open" Systems And Approximately 541 Million Were Used In "Long Lived Contained" Systems

(2) During The Period From 1957 Through 1971, Approximately 46% Of Aroclors Sold In The U.S. Were The Least Persistent Trichloro Or Lower Chlorobiphenyls (12)

(3) An Estimate Of The Total Aroclor Used In The U.S. In Electrical Systems Since 1934 Is 752 Million Lbs.

(4) An Estimate Of The Total Aroclor Used In The U.S. In Non-Electrical Systems Since 1934 Is 367 Million Lbs.

(5) An Estimate Of The Reasonable Upper Limit On Total PCB Consumption In The U.S. Since 1934 Is 1,175 Million Lbs., Assuming A 5% Conservative Margin For Imports And Statistical Uncertainty

(6) Before 1971 There Were 10 to 15,000 Direct Purchasers Of Aroclors, While Currently There Are 25-30

. These purchasers ordered Aroclors directly from Monsanto

. Papageorge (36) reported that the order of magnitude of purchasers of Aroclor in 1971 or before in each end-use category is as follows:

- Heat Transfer	:	2,000
- Hydraulics	:	3,000
- Lubricants	:	"few"
- Misc. Industrial	:	"several thousand"
- Transformers and Capacitors	:	40-50
- Plasticizer Applications	:	2,000

MONS 043566

- Many of these purchasers were distributors further disbursing PCBs to countless small accounts (36)

- Since Monsanto's voluntary restriction of sales and other control actions, there are currently 25-30 direct customers, all in transformer and capacitor applications. These customers use PCBs askarels in the finished products (capacitors and transformers) or in the course of servicing.

10. 1973 USE OF PCBs BY THE U.S. ELECTRICAL INDUSTRY IS ESTIMATED AT 36 MILLION POUNDS AND IS EXPECTED TO INCREASE TO ABOUT 51 MILLION POUNDS BY 1978

(1) The Average Annual Growth Rate For PCB Use By The Electrical Industry During The 1963-1973 Period Is 4.6% And This Is Expected To Increase To About 7.4% Through 1978

(2) Present Production And Handling Procedures Adopted By Major Transformer And Capacitor Manufacturers (16) Minimize Environmental Contamination (50)

(3) The Capacitor And Transformer Manufacturing Industry Is A Highly Concentrated Industry

- According to the National Electrical Manufacturers Association (16), its member companies have the major share of this market to the utility industry.

  - 22 transformer producers
  - 6 capacitor producers

- According to the Certified Ballasts Manufacturers Association (53) there are only 10 manufacturers of fluorescent lamp ballasts.

(4) The Consumer Sector (Principally Electric Utilities) Is Becoming Increasingly Conscious Of The Need To Reduce Environmental Contamination

(5) The Value Of Imported Transformers In 1973 Is Estimated At 50 Million And Is A Small Portion Of Total Transformer Sales

- Probably only few imported transformers contain insulating oils due to shipping, handling and economic considerations.

. There is indication that probably relatively insignificant numbers of askarel type transformers are imported.

(6) Near Term Replacement Of PCBs In Most Askarel Electrical Applications Is Technically Not Feasible

11. OPEN SYSTEMS END-USES HAVE ENCOMPASSED A BROAD RANGE OF APPLICATIONS IN WIDELY DISTRIBUTED PRODUCTS AND PROCESSES

(1) The Applicability Of PCBs In Open Systems Is Wide-Ranging

(2) In Most Open Systems Situations The Concentrations Of PCBs Associated With The Product/Process Have Probably Been Low Percentages

(3) During The Next Five Years, Imports Are Expected To Be Essentially The Sole Source Of Fresh PCBs In Open System End-Uses With Investment Casting Accounting For A Major Portion

12. BASED ON A SNELL LIFE CYCLE MODEL, ABOUT 500 MILLION LBS. OF PCBs ARE IN-SERVICE, ESSENTIALLY ALL IN ELECTRICAL APPLICATIONS

(1) Nelson (38) Estimated That The Equivalent of 80% Of The Annual PCB Usage Was Scrapped In 1970

(2) A Life Cycle Model Developed From Further Evaluation Of Nelson's (38) Assumptions Regarding The Scrappage Rates Of PCBs, Indicates That The Equivalent Of Only About 26% Of The Annual PCB Usage Was Scrapped In 1970

. The total amount of PCBs in-service through the end of 1973 was estimated using the model. The table below presents in-service estimates by end-use category.

End-Use	PCB Quantity In-Service Through 1973 (million lbs.)
Transformers	205
Capacitors	270
Heat exchangers	11
Plasticizer applications	negligible
Hydraulic fluids and lubricants	9
Miscellaneous industrial applications	negligible
Total	495

MONS 043568

- At the end of the next five years only a negligible amount of PCBs will still be in non-electrical service.

13. SIGNIFICANT STEPS HAVE ALREADY BEEN TAKEN TO ENVIRONMENTALLY MANAGE PCBs IN PRODUCTION, CONSUMPTION AND COMMERCE

(1) The Monsanto Company, The Sole U.S. Producer, Has Led Environmental Control Of PCBs

(2) The Market Statistics Suggest That The Great Majority Of Open System Users Of PCB Have Found Alternatives To This Commodity, But There Has Not Been A Sense of Urgency To Eliminate PCBs Already In Service

(3) The Current Buyers Of PCBs For Capacitor And Transformer Insulation Have Taken Formal Steps Toward Environmental Control

(4) The Control Of PCBs Already In The Environment Is Not Feasible, Except In Highly Localized Situations

(5) Regulatory Action Can Assure Enforcement Of Controlled Use Of PCBs In The Future

SECTION II

SECTION II

RECOMMENDATIONS

In this section recommendations are presented related to further work to define the movement of PCBs through the commercial and wastage cycle. Other recommendations address PCB management strategies.

1. IN-DEPTH SURVEY OF THE ELECTRICAL INDUSTRY IS RECOMMENDED

The purpose of the proposed survey is to obtain detailed information of PCB use practices in the electrical industry, which now accounts for essentially all the PCBs consumed in the U.S. There is strong evidence that in the near-term replacement of PCBs in the current electrical uses would pose serious technological as well as institutional problems.

The scope of the proposed survey is to define in-depth

- shipping and handling of PCBs for electrical end-uses
- transformer and capacitor manufacture and use technology
- environmental protection practice
  - technical
  - administrative
- market configurations
  - production and distribution of askarel capacitors and transformers
  - use of these
  - forecasts of production, distribution and use
- research and development status
  - replacement of PCBs
  - environmental controls

MONS 043571

- economic impact of limiting PCB use in the electrical industry with respect to specific management strategies

The proposed survey methods include literature review and telephone and visit survey of individual firms through the coordination of industry associations.

Without economic impact assessment, the estimated level of effort required is 8-10 man-months over a four month performance period.

MONS 043572

2. EVALUATION OF SELECTED PCB MANAGEMENT OPTIONS IS RECOMMENDED

Study of the following PCB management concepts is recommended:

- Formal banning of the sale or purchase of PCBs for non-electrical uses, and the granting of exemptions on a case-by-case basis
- Formal sanctioning of the National Standard Guidelines For Handling and Disposal of Capacitor - And Transformer - Grade Askarels Containing Polychlorinated Biphenyls
- Establishing an enforcement mechanism that also applies to importing of PCBs

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SECTION III

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SECTION III

INTRODUCTION

In conjunction with its hazardous materials control activities, the Office of Toxic Substances of the United States Environmental Protection Agency (EPA) has issued the second task order to Foster D. Snell, Inc. (Snell) under Contract No. 68-01-2106 to prepare a report on the "Market Input/Output Profile, Process Technology Assessment, And Entry Into The Environment Of Polychlorinated Biphenyls (PCBs)". The report summarizes the findings developed during the six week, rapid response effort to assemble this information from literature review, market research, technology assessment and selective interviewing of industry sources.

1. PURPOSE

There is need for improved definition of the movement of PCBs through the various production/consumption/wastage steps of our complex economy, both in terms of the respective PCB quantities and processes involved. The purpose of this study is to assimilate existing scattered information pertaining to this for an integrated definition, and to identify further information needs.

The study outputs are designed to aid EPA in understanding the historical and current commercial status of PCBs and to provide technical support to decision-making regarding the control of these substances.

2. APPROACH AND SCOPE

The rapid response effort to this task order is based upon literature search and review, selective interviews with industry sources, patent summarization and technology assessment, and market research.

To obtain pertinent references on polychlorinated biphenyls, in addition to the Snell and EPA (Washington) libraries, the following places were visited: The Chemist's Club (N.Y.), Commerce Department Library (N.Y.), Custom's Bureau (N.Y.), the Tariff Commission (N.Y.), and the Engineering Society Library (N.Y.). The card catalogs of the libraries were reviewed and the following indices were perused:

- Business Periodicals
- Engineering

MONS 043575

EXHIBIT IV (1)
EPA
PATENT DIGEST

PROCESSES FOR THE PREPARATION OF PCBs

3,717,685 February 20, 1973
Russell G. Hay, Vincent A. Notaro, Charles M. Selwitz
Gulf Research & Development Company
PROCESS FOR PREPARING CHLORINATED AROMATICS

A process for preparing a chloroaromatic compound which involves heating an aromatic compound in the presence of a nitrate ion, a nitrite ion, NO or NO_2, HCl, water, oxygen, a strong acid and a paraffin or a cycloalkane.

3,717,684 February 20, 1973
Vincent A. Notaro, Charles M. Selwitz
Gulf Research & Development Company
PROCESS FOR PREPARING CHLORINATED AROMATICS

A process for preparing a nuclear polychloro alkyl aromatic compound which involves heating an alkyl aromatic in the presence of a nitrate ion, a nitrite ion, NO or NO_2, HCl, water, oxygen and a strong acid, wherein the molar ratio of HCl to aromatic compound is initially at a level of about 4: 1 to about 10: 1 and such ratio is maintained at approximately such level during the course of the reaction.

3,655,523 April 11, 1972
Harold O. Seeburger, Lee H. Horsley
The Dow Chemical Company
METHOD FOR SEPARATING A 2- AND 4-CHLOROBIPHENYL FROM THE CORRESPONDING HYDROXY BIPHENYL COMPOUNDS

2-Chlorobiphenyl, 4-chlorobiphenyl or mixtures thereof may be separated from a mixture with the corresponding hydroxybiphenyl compound by adding to the mixture of such compounds an azeotropic agent which is a glycol, glycol monoalkyl or phenyl ether, glycerol, glycerol alkyl ether, alkanolamine or dialkylenetriamine having a boiling point within about 45°C. of the halobiphenyl compound at atmospheric pressure, and then fractionally distilling the mixture thus formed at a pressure of up to about 200 mm. Hg. absolute.

3,547,790 December 15, 1970
Bobby F. Dannels and Alvin F. Shepard
Hooker Chemical Corporation
AROMATIC CONDENSATION PRODUCTS

A process for producing aromatic condensation products comprises passing an electric current between a cathode and an anode in contact with liquid phase hydrogen fluoride, wherein the hydrogen fluoride is also in contact with an aromatic compound having a hydrogen atom substituted in at least one position of the aromatic ring. The polymer products have excellent heat resistance and electrical insulation properties and can be coated on other types of polymers to modify the surface characteristics thereof. The polymers can be converted to sulfonated polymer products.

3,539,622 November 10, 1970
Richard F. Heck
Hercules Incorporated
PROCESS FOR PRODUCING DIARYL COMPOUNDS

A process for producing a diaryl compound which comprises an aryl mercuric salt in which the aryl group contains a benzene ring to which the mercury is directly attached with a palladous salt at a temperature in the range of 20 to 150°C.

3,145,237 August 18, 1964
Robert van Helden, Govert Verberg, and Bob Balder
Shell Oil Company
POLYNUCLEAR AROMATIC COMPOUNDS

The process for the intermolecular condensation of aromatic compounds, which comprises contacting an aromatic compound having a labile hydrogen atom attached to an aromatic nucleus, in liquid phase, with a salt selected from the group consisting of the salts of the palladium and platinum group metals with an acid selected from the group consisting of mineral acids, aliphatic monocarboxylic acids and sulfonic acids, under substantially anhydrous conditions, at a temperature of from about 40 to 200°C., in the presence of a member of the group consisting of the oxides and salts of the alkali metals and alkaline earth metals.

3,072,728 January 8, 1963
Milton Kosmin and Richard L. Wasson
Monsanto Chemical Company
METHOD OF PREPARING HALOGENATED DIPHENYL COMPOUNDS

A process for the preparation of individual, preselected halogenated diphenyls or diphenyl ethers which calls for the reaction of o-chlorophenol, 1-chloro-2-nitrobenzene and potassium hydroxide to form 2-chlorophenyl 2-nitrophenyl ether. This product is then reduced to 2-chlorophenyl 2-aminophenyl ether. The latter ether must be diazotized, after which the diazonium salt is finally converted to the desired bis (2-chlorophenyl) ether.

3,068,297 December 11, 1962
Harold I. Weingarten
Monsanto Chemical Company
ISOMERIZATION OF HALOBIPHENYLS

The invention relates to an improved process for effecting the conversion of by-product halogenated biphenyls to more useful liquid dielectric compositions having an improved dielectric constant. The by-product dihalogenated biphenyl compositions, particularly those rich in 2, 2'-dihalobiphenyl can be isomerized in the presence of aluminum chloride and anhydrous hydrogen chloride at temperatures from about 50°C., to about 250°C. and more preferable still from about 70°C. for a time of from about 15 minutes to about 10 hours or more and preferable from about 1 hour to about 5 hours.

3,029,295 April 10, 1962
Robert Thermet and Ludovic Parvi
Societe d'Electro-Chimie d'Electro-Metallurgic et des Acieries Electriques d'Ugine
PREPARATION OF POLYCHLORINATED DIPHENYL DERIVATIVES

A method of preparation, in a single stage of chlorinated diphenyl derivatives having a degree of chlorination up to 100% by passing a gaseous stream containing a chlorine gas ingredient and a diphenyl ingredient as essential ingredients through a fluidizable bed of divided material, maintaining the temperature in the bed at a value of at least as high as the boiling point of a desired diphenyl derivative, and regulating the rate of throughflow of said gaseous stream so as to maintain said bed in a state of stationary dense fluidization. This invention relates to a method of producing polychlorinated diphenyl derivatives, and more specifically the higher chlorinated derivatives of diphenyl, such as decachlorodiphenyl and products of approaching composition.

3,007,975 November 7, 1961
John T. Massengale and Theodore H. Fairbanks
American Viscose Corporation
4,4' BIS-(CHLOROMETHYL)-BIPHENYL

A process of preparing 4,4'-bis-(chloromethyl)-biphenyl which comprises reacting biphenyl, formaldehyde and hydrogen chloride in the presence of a catalyst system comprising zinc chloride and water in a weight ratio at the start of the reaction of about 1.5 to 4 parts of zinc chloride to 1 part of water and wherein said zinc chloride is present in a ratio of 1.2 to 2.55 moles of zinc chloride per mole of biphenyl present at the start of the reaction.

1,892,400 December 27, 1932
Russell L. Jenkins and Joseph A. Sikaraki
Swann Research, Inc.
DIPHENYL RESIN AND METHOD OF PRODUCING THE SAME

This invention related to diphenyl resins, and in particular to a process by which resins having predetermined properties may be produced. This process for the production of diphenyl by thermal synthesis, preheated benzol vapors are pumped through a bath of a molten salt or molten metal, such as lead, said bath being maintained at the diphenyl forming temperature of about 850°C.

1,892,398 December 27, 1932
Russell L. Jenkins
Swann Research, Inc.
NONCRYSTALLINE HIGHLY CHLORINATED DIARYL RESIN

The invention relates to the production of non-crystalline highly chlorinated diaryl resins wherein various percentages of complex high boiling compounds which are formed as a by-product in the thermal synthesis method of producing diphenyl are mixed with the diphenyl before chlorination. The diphenyl is separated from the product of the diphenyl reaction by distillation.

1,892,387 December 27, 1932
Russell L. Jenkins
Swann Research, Inc.
PROCESS FOR THE PRODUCTION OF CHLORINATED DIARYLS

This invention relates to a method for the production of chlorinated diaryls and has for its object the provision of means whereby varying amounts of chlorine may be substituted in diphenyl, or other diaryls or substituted diaryls, to produce compounds having physical properties ranging all the way from light oils to solids or semi-solids at ordinary temperatures. In the process for the catalytic production of chlorinated diphenyl, inducing and maintaining a thermosyphonic flow of the reacting mass through the catalyst by means of the action of the presence of the catalyst.

EXHIBIT V (1)
EPA
PROCESS FLOW AND ENVIRONMENTAL CONTROLS AT MONSANTO'S SAUGET PLANT

1. Process Flow*

DISTILLED BIPHENYL AND ANHYDROUS CHLORINE →	REACTORS →	HOLDING AND NEUTRALIZATION TANKS ⟶	DISTILLATION UNIT →	HOLDING TANKS →	BLENDING AND SHIPPING
. Biphenyl purity is controlled	. Batch or cascade	. Flexible, closed tankage	. Gas fired	. Product storage	. Dilution with chlorobenzenes
	. Scrap iron catalyst	. Lime neutralization	. First cut is recycled to reactor	. Flexible closed tankage	. Drumming or tank car filling
			. Heart cut is product		
			. Heel cut is drummed, diluted and incinerated		

* Source: References 11, 36

MONS 043679

EXHIBIT V (2)
EPA
PROCESS FLOW AND ENVIRONMENTAL CONTROLS AT MONSANTO'S SAUGET PLANT (continued)

2. Environmental Controls**

- Drainage is directed to trenches and piping, and then to one of two 3,000-gallon settling basins. Pads are curbed. This insures PCB containment in case of accidental spill or equipment failure.

- When small quantities of PCB's are collected into the settling basins in the manufacturing area they are later pumped into drums, and eventually incinerated.

  - In the incinerator area itself, drainage is directed to trenches and piping which flow into a 10,000-gallon basin.

  - Recovered PCB's are periodically pumped to storage, or incinerated.

- In the manufacturing area, rupture disc lines and atmospheric vents have been rerouted through catch tanks, or redirected to settling basins. This insures that if a rupture does occur, PCB's will be contained in a controlled area.

- Nitrogen blanketing on storage tanks has been provided to eliminate any "breathing" of the tanks and resultant PCB escape.

- Mist eliminators have been installed in vapor lines.

** Source: References 14, 36, 37

MONS 043680

EXHIBIT V (3)
EPA
PROCESS FLOW AND ENVIRONMENTAL CONTROLS AT MONSANTO'S SAUGET PLANT (continued)

- Underground sewers have been replaced with aboveground sewers, and others repaired or combined, to enable monitoring of the effluent from the department. In addition, this prevents any unknown buildup of PCB's in the sewer systems or any contamination of PCB's into other sewers.

- Among the housekeeping responsibilities operators have assumed are these:

  - All pumps are checked for leakage on every shift. Drip pans that collect leaks are emptied into scrap PCB drums.

  - All leaks are reported and documented so that corrections can be made and settling basins observed.

  - "Floor Dry" is used to absorb any liquid PCB's that have spilled or leaked. If it becomes necessary to flush PCB's to the settling basin, a minimum amount of water is used.

  - Sampling drums and scrap-PCB drums are quickly palletized, labeled, and transferred to the incineration area.

MONS 043681

EXHIBIT V (4)
EPA
PROCESS FLOW AND ENVIRONMENTAL CONTROLS AT MONSANTO'S SAUGET PLANT (continued)

- Systems to monitor effluent have been developed
  - PCB content in the parts-per-billion range can be determined.
  - The minimum detection level in wastewater is 100 ppb ± 25%.
  - Monitoring is continuous.
- Loading and shipping safeguards have been established to minimize accidental PCB loss during transportation. Specific written instructions are on every container shipped.

MDNS 043682

EXHIBIT VI
EPA
SHIPPING OF AROCLOR PLASTICIZERS
(47)

Freight Classification

Aroclor 1221, 1232, 1242, 1248, 1254, 1260, 1262	Synthetic Resin, Liquid, NOIBN

Rail Classification

Aroclor 1268, 4465, 5442, 5460	Synthetic Resin, Other Than Liquid, NOIBN

Truck Classification

Aroclor 1268	Synthetic Resin, Powder, NOI
Aroclor 4465, 5442, 5460	Synthetic Resin, Lumps or Solid Mass, NOI

Standard Containers

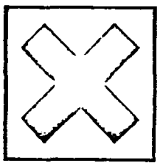
Aroclor 1221	Tank car, 520 lb. steel drum, 50 lb. can
Aroclor 1232	Tank car, 550 lb. steel drum, 50 lb. can
Aroclor 1242,1248, 1254, 1260, 1262	Tank car, 600 lb. steel drum, 50 lb. can
Aroclor 1268	200 lb. fiber drum, 25 lb. fiber drum
Aroclor 4465	500 lb. steel drum, 50 lb. can
Aroclor 5442	450 lb. steel drum, 50 lb. can
Aroclor 5460 (flaked)	50 lb. bag

MONS 043683

EXHIBIT VII (1)
EPA
EXAMPLE OF CURRENT AROCLOR
LABELING PRACTICE

AROCLOR® 1254

DIELECTRIC FLUID BY **Monsanto**



Substances nocives
Harmful substances
Gesundheitsschädliche Stoffe
Sostancias nocivas
Sostanze nocive

Xn

CAUTION!

CONTAINS CHLORINATED HYDROCARBONS

Read and follow all IMPORTANT safeguard instructions shown on this container.

WASTE DISPOSAL

With prior Monsanto notification used polychlorinated biphenyl fluids may be returned freight prepaid for proper incineration at 3¢ per pound.

Ship to: Supervisor Dept. 831
MONSANTO COMPANY
SAUGET, ILLINOIS 62201

LOT NO. _____ PACKER _____

LEGAL NET 60 LB. 27.22 KG.

TARE 5 LB. 2.27 KG.
GROSS 65 LB. 29.49 KG.

MONSANTO COMPANY, ST. LOUIS, MISSOURI 63166, U.S.A.

811.03-280.19/53

MONS 043684

EXHIBIT VII (2)
EPA
EXAMPLE OF CURRENT AROCLOR
LABELING PRACTICE

ENGLISH IMPORTANT **CHLORODIPHENYLS (42 % - 54 %) (or 60 %) (PCB)**

This product contains POLYCHLORINATED BIPHENYLS (PCB's) which some studies have shown may be persistent, an environmental contaminant and, possibly, injurious to certain forms of bird, aquatic and animal life.

PREVENT ANY ENTRY INTO THE ENVIRONMENT THROUGH SPILLS, LEAKAGE, DISPOSAL, VAPOURISATION, RE-USE OF CONTAINERS OR OTHERWISE.

SPILLS, LEAKAGES AND WASTE PRODUCT MUST BE COLLECTED.

Use of this product must be restricted to applications which can be controlled so that entry into the environment does not occur and to applications in which it cannot come into contact with food, animal feedstuffs or pharmaceuticals.

HARMFUL SUBSTANCE IF TAKEN INTERNALLY OR IF IN PROLONGED CONTACT WITH THE SKIN.
CAUSES IRRITATION OF SKIN AND EYES.
DURING SHIPMENT AVOID SPILLS AND LEAKAGE INTO INLAND WATERWAYS AND THE SEA.
Store away from food, animal feedstuffs and pharmaceuticals.
Keep container tightly closed.
Do not eat or smoke when using.
Avoid breathing vapours, mist or fumes.
Do not wear contaminated clothing.
Wash product from skin with soap and water.
Wash eyes by flushing with water.

THIS COPY, THIS SIZE, IN SEVEN LANGUAGES IS PAINTED ON 30 AND 55 GALLON DRUMS USED FOR PCB SHIPMENTS.

MONS 043685

EXHIBIT VIII (1)
EPA
*EXCERPTS FROM NEMA'S PROPOSED
ENVIRONMENTAL CONTROLS

SECTION 2
CAPACITOR GUIDELINES

I. INTRODUCTION

There are two general classes of askarels used by the electrical industry. The higher chlorinated grades are the more persistent in nature. Because of their high degree of nonflammability, they are used in transformers where personnel safety is of paramount importance.

Capacitor-grade askarel has a lower degree of chlorination (composed primarily of the 3-chlorine isomers of biphenyl) and a higher degree of biodegradability. It is used in capacitors where the extreme degree of nonflammability required in transformers is of less importance.

II. CAPACITOR-GRADE ASKAREL

In September of 1971, a new grade of capacitor impregnant, Aroclor 1016, was made available to the industry. This new grade contains a typical concentration of 0.4 percent by weight of the higher boilings homologs of the chlorinated biphenyls. Aroclor 1016 replaces Aroclor 1242 which previously was the major capacitor impregnant and contained around 7 percent of the higher boiling homologs (the more persistent in nature). This 0.4 percent level of the higher boiling homologs should be the maximum concentration acceptable in any capacitor impregnant. Aroclor 1242 and 1254, previously used as impregnants, do not meet this requirement and should no longer be used in capacitors designed and manufactured for alternating-current applications.

Aroclor 1016 has the same UL nonflammability rating as Aroclor 1242.

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*Excerpts From The National Electrical Manufacturers Association (NEMA) Official Standards Proposal (16) For Handling And Disposal Of Capacitor - And Transformer-Grade Askarels Containing PCBs.

III. PLANT HOUSEKEEPING AND EMPLOYEE SAFETY

A. Material

Askarel for use in capacitors should consist of homologs and isomers of chlorinated biphenyl with the concentration of the higher boiling homologs at about 0.4 percent.* Aroclor 1016 is considered to be the standard impregnant meeting these requirements.

Commonly used solvents include benzene, kerosene, acetone, trichloroethane, trichloroethylene and perchloroethylene. Typical vapor pressure data for Aroclor 1016 are:

0°C	=	0.001 mm
25°C	=	0.006 mm
150°C	=	4.3 mm
200°C	=	28.0 mm

At 25°C and 760 mm Hg pressure, saturated air contains approximately 0.09 mg/liter.

1 mg/liter	=	90.0 ppm (v/v)
1 ppm (v/v)	=	0.011 mg/liter

B. Bulk Fluid Shipment, Receiving, and Transfer

Shipment of askarel from point of manufacture to point of receiving should be done in closed containers such as rail, tank cars, truck tanks, marine or barge tanks, or sealed drums. Containers should be labeled as to contents and carry a label cautioning against loss of fluid to the open environment. Containers used to transport askarel should not be used for storage or to transport other material without being completely cleaned of all traces of askarel.

* Monsanto Method T-02302

(Cleaning procedures must take cognizance of precautions against excessive exposure and of the need for proper disposal of contaminated cleansing solvents and materials). Transfer from shipping containers to processing systems should be through closed piping or tubing with appropriate valves, pumps, etc. Provision should be made for trapping and disposing of fluid lost by leakage or spills from the transfer system and from the storage containers.

Drums to be retired from use should be cleaned before crushing, delivery to scrap dealers, or other disposal. Contaminated cleaning fluids and materials should be disposed of as indicated in Part V.

C. General Safety Precautions

1. Vapors

Breathing vapor or fumes from heated askarel should be avoided. Provisions should be made for adequate ventilation and regulation of manufacturing operations to avoid open exposure to askarel (especially at 55°C or higher). The gases produced when askarel is decomposed by very high temperatures (such as that of an electric arc) in the presence of air or organic insulating materials contain a high percentage of hydrogen chloride, and small percentages of carbon dioxide, carbon monoxide and oxygen. Minute concentrations of this combination of gases are very unpleasant and irritating, thus giving ample warning of their presence. If exposure to high concentrations of askarel is necessary under emergency conditions, an approved gas mask or self-contained breathing apparatus should be worn. Such exposure should be under the surveillance of other personnel capable of rescue in case of an accident. If the odor of askarel is detected by the person wearing protective equipment, he should immediately go into fresh air. All gas masks, respirators and replacement parts should have Bureau of Mines approval and be maintained on a regular schedule in accordance with the manufacturer's recommendation.

- Applied Science and Technology
- Funk and Scott
- Predicasts
- Chemical Marketing Abstracts
- Chemical Engineering
- Government Reports
- Search

The useful citations obtained are contained within the bibliography accompanying the report.

In addition, personal communication was established with the following sources:

- Monsanto Industrial Chemicals Corporation
- National Electric Manufacturers Association (NEMA)
- Edison Electric Institute (EEI)
- Selected transformer and capacitor manufacturers
- Other industry sources

The cooperation of the Monsanto Industrial Chemicals Company, the sole U.S. producer of PCBs, is acknowledged.

MONS 043576

SECTION IV

SECTION IV

PRODUCTION QUANTITIES

In this section market statistics are presented regarding the sources of polychlorinated biphenyl (PCB) products.

1. PCB PRODUCTS ARE MIXTURES OF VARIOUS HOMOLOGS OF CHLORINATED BIPHENYL

Whenever aromatic hydrocarbons such as biphenyls are chlorinated, the product is a mixture of compounds, including isomers. The Inter-departmental Task Force on PCBs (1) summarized the composition of the different liquid chlorinated biphenyl products used predominantly in the U.S., as shown in the first page of Exhibit I. The second page of the exhibit shows typical percent composition of the materials currently marketed.

(1) Contaminants And Impurities In The Product Are Determined By The Quality Of The Starting Materials And Process Conditions

- Fractionation of samples of some PCBs of foreign manufacture indicated the presence of tetra and pentachlorodibenzofurans and hexa-and heptachloro-naphthalenes (1, 20)

- Papageorge (36) indicated that, within the limits of detectability, PCBs produced by the Monsanto Industrial Chemicals Company have not been found to contain these impurities.

  - Monsanto uses biphenyl feedstock of high purity

  - Monsanto neutralizes the reaction mass with lime rather than caustic soda (used in Europe)

(2) The Unique Physical And Chemical Properties Of PCBs Have Made These Substances Technically Attractive In A Variety Of End Uses

- The most important physical properties of PCBs are low vapor pressures (high boiling points), low water solubility, and high dielectric constants. They are miscible with most organic solvents and compatible with many types of polymers. Although some individual PCB compounds are crystalline, commercial mixtures have been either liquids or resins.

- The chemical properties that make PCBs desirable industrial materials are: excellent thermal stability, strong resistance to both acidic and basic hydrolysis, general inertness and resistance to oxidation.

- Specific data on these properties are summarized in the Encyclopedia of Chemical Technology (11).

(3) PCBs Have Been In Commercial Use In The U.S. Since The 1920s

- This represents over 40 years of industrial application.

- Early applications of PCBs were primarily as insulating fluid in the electrical industry and as heat transfer fluid (14).

- In the early 1960s several new applications were promoted (14).

(4) The Tetrachloro And Lower Chlorobiphenyls Appear Less Persistent In The Environment Than The Higher Chlorobiphenyls

- Nelson (38) summarizing the findings of several workers found evidence supporting this conclusion.

- Tucker of Monsanto (12) also concluded this and made the following correlation based on the homolog distribution of PCBs sold by the company from 1957 to 1971.

MONS 043579

PCB Chlorine Homolog	Percent Homolog in Monsanto U.S. Sales 1957-1971	Percent Homolog in Laboratory Aged Aroclor 1254, (Similar to PCBs Found in Environmental Samples)
0	0.1	.1
1	1.3	.1
2	14.8	.5
3	29.9	1
4	21.9	21
5	16.1	48
6	10.5	23
7	4.2	6
8	1.1	Not Detectable

2. THE MONSANTO INDUSTRIAL CHEMICALS COMPANY IS THE SOLE U.S. PRODUCER OF PCBs

There is no evidence in the literature that other companies have produced PCBs domestically in appreciable commercial quantities. There is evidence, however, that PCBs have been imported.

The tradename used by Monsanto for these products is Aroclor. Some principal industrial purchasers of Aroclors use the product under their own trade names.

3. MONSANTO'S CURRENT APPROXIMATE NAMEPLATE PRODUCTION CAPACITY IS 48 MILLION LBS. PCBs PER YEAR (36)

Until 1971 these materials were produced at two locations.

Plant Location	Capacity (Million lbs.)
Anniston, Alabama	48
Sauget, Illinois (Wm. G. Krummrich Plant)	48

The Alabama plant was dismantled in April, 1971. Nameplate production capacity of the two facilities was approximately 96 million lbs. (36).

The 1973 projected production at the Illinois plant is approximately 43 million lbs. (37). This represents about 90% utilization of capacity.

MONS 043582

4. ANNUAL STATISTICS FOR U.S. PRODUCTION AND SALES OF AROCLORS SHOW MARKED DECREASE IN USAGE CAUSED BY RESTRICTION TO ELECTRICAL APPLICATIONS SINCE 1971

These data, appearing in Exhibit II, specify Aroclor as well as end-use categories. Export data are also presented.

(1) Monsanto No Longer Sells PCBs For End-Uses Other Than Capacitor And Transformer Insulating Liquids

. This voluntary restriction by the essentially sole source of PCBs for U.S. consumption was motivated by appreciation of the difficulties involved in imposing workable environmental controls in the other end-use categories (12, 36, 37).

. Sales for heat transfer were phased out in 1972 while sales for other non-electric uses were discontinued in 1971.

(2) Specific End-Uses, Including Those For Which Sales Were Phased Out By Monsanto Are Correlated With Aroclor Type In Exhibit III

(3) Domestic Sales Of Aroclors Are Expected To Increase At An Average Annual Rate Of 7.4% Over The Next Five Years

. Papageorge (36) indicated that for planning purposes Monsanto preliminarily expects a 6% annual growth rate in sales, all for capacitor and transformer applications.

. Growth in Aroclor sales will depend on the outlook for askarel (PCB) type capacitors and transformers (36).

. Selective interviews with industry sources and correlations with Predicast projections (42) indicate the following annual growth projections through 1978

- askarel use in capacitors: 6 %
- askarel use in transformers: 10 %
- PCBs: 7.4 %

See Section VI for in-depth discussion.

MONS 043583

5. THE PATTERN OF WORLD COMMERCE IN PCBs INDICATES LOWER FUTURE PRODUCTION AND RESTRICTED USAGE

(1) Import Statistics Indicate That Only About 2% of PCBs Sold In The U.S. Were Imported In 1971 And About 1.4% In 1972

- According to U.S. Tariff Commission records 354, 593 lbs. PCBs were imported in 1972, and 640, 610 lbs. in 1971 (39).

- Before 1971 this information was lumped in a general chlorinated hydrocarbons category in these records.

- Pursuant to Customs Bureau Directive CIE 36-72, July 14, 1972 the field offices of the Customs Bureau have been specifically monitoring the inflow of PCBs, and this information is forwarded to EPA (40). The information is not public.

- It should be noted that the quality of import statistics as well as the effectiveness of monitoring PCB inflow can be influenced by

  - how the imported chemicals are labeled and represented

  - whether or not PCBs are a principal component or lesser ingredient of imported chemicals

  - whether or not PCBs are an integral part of transformers and capacitors or products with these as components, or in rubbers, plastics and adhesives. These are the principal products with which imported PCBs are thought to be associated (38).

  - the extent to which the above information is available during the importation cycle.

MONS 043584

(2) Imports of PCBs Are Expected To Be Less Than 2% of Total U.S. Sales During The Next Five Years

. This is the same order of magnitude as the 1971 and 1972 imports.

. The decline in world commerce is expected to be reflected also in imports.

(3) During The Period From 1963 Through 1972 Exports of Aroclors Were 78.7 Million Lbs.

. This represents 15% of U.S. sales of Aroclors over this period, which were 522.4 million lbs.

. Exports of Aroclors to Canada are estimated to have been about 7% of U.S. sales, or about one-half the total exports (38).

(4) Exports of Aroclors Are Expected to Maintain The Same Ratio To U.S. Sales As In The Past Several Years (36), Or 10-15%

(5) Known Foreign Producers of PCBs Include Czechoslovakia France, Germany, Italy, Japan, Spain, and The U.S.S.R.

. Several tradenames have been reported (11,38)

- France: Pyralene and Phenoclor (Prodelec)
- Germany: Clophen (Farbenfabriken Bayer)
- Japan: Kannechlor (Kanegafuchi Chemical); Santotherm (Mitsubishi-Monsanto)
- Italy: Fenclor (Caffaro)
- Spain: (Electro-Quimica de Flex)
- U.S.S.R.: Sovol

MONS 043585

- Producers in France, Germany, Japan, Italy and Spain are the most likely sources of imported materials.

- Possible new producers may be located in Argentina, Brazil, East Germany and India (1).

- Historical use and loss patterns of PCBs are expected to be broadly similar in all industralized countries (38).

- Total production of PCBs outside the U.S. have been roughly estimated to equal the U.S. production (1), corresponding to an annual rate of up to 80 million lbs.

- The combined PCB output of the Western European producers, Prodelec, Bayer, Caffaro and Electro-Quimica de Flex, was 75 million lbs. in 1971.

- In 1970 it was reported that Japan was producing PCBs at an annual rate of 26 million lbs. (38).

-	capacitors:	40-50%
-	transformers:	15%
-	heat transfer:	10-15%
-	plastics:	5%
-	carbonless paper:	15%
-	export:	5-10%

- The use and production of PCBs was recently banned in Japan, but manufacture of PCB bearing products (such as air conditioners with askarel capacitors) by Japanese interests for export may be taking place in Taiwan (36). There is evidence of exemptions to the ban (36).

- World-wide, the non-U.S. production of PCBs has also probably decreased

  - due to the Japanese action noted above

  - due to the recent agreement of the Organization for Economic Cooperation and Development (OECD) to limit sales principally to use in transformers and capacitors and some minor essential heavy industrial applications (31).

MONS 043586

- Farbenfabriken Bayer stopped marketing PCBs for plasticizer uses before the OECD agreement (41).

(6) World Commerce In PCBs Is Expected To Decrease By About The Same Amount Or More Than In The U.S. Since 1970, And To Be Essentially Confined To Capacitor And Transformer Applications

- Japan will not produce PCBs
- The 1970 Aroclor production was 85 million lbs. Estimated 1973 production is 43 million lbs., accounting for a 50% reduction
- Western Europe will produce 30-40 million lbs. annually
- In the long run the remaining world producers will also show a pattern of reduced PCB production in the wake of developments in the U.S., Western Europe and Japan.

MONS 043587

EXHIBIT I (1)
EPA
COMPOSITION OF DIFFERENT
LIQUID PCB PRODUCTS

Components Given as %	Monsanto Aroclors (1)							
	1221	1232	MCS 1043	1242	MCS 1016	1248	1254	1260
Chlorine*	21	32	32	42	42	48	54	60
Biphenyl	14.8		.04	.02	.02			
Mono-chlorobiphenyl	56.5		22.2	.72	.93			
Di-chlorobiphenyl	26.9	~55	74.4	15.6	19.4			
Tri-chlorobiphenyl	1.42		3.3	54.5	64.5			
Tetra-chlorobiphenyl	.06			22.5	15.0	~55		
Penta-chlorobiphenyl				6.7**	.16**		60	
Hexa-chlorobiphenyl								70

* The last two digits of each Aroclor type indicate the percent chlorine content, except for MCS 1016 and 1043.

** Includes higher than penta-chlorinated isomers.

MONS 043588

EXHIBIT I (2)
EPA
COMPOSITION OF DIFFERENT
LIQUID PCB PRODUCTS
(continued)

Homolog Distribution of Aroclors Currently Marketed (12)

Homolog No. of Cl/Biphenyl	Percent Composition*			
	1221	1016	1242	1254
0	11	<0.1	<0.1	<0.1
1	51	1	1	<0.1
2	32	20	16	<0.5
3	4	57	49	1
4	2	21	25	21
5	<0.5	1	8	48
6	ND**	<0.1	1	23
7	ND	ND	<0.1	6
8	ND	ND	ND	ND

* Percent (w/w) by GC/Mass using area correction factors

** None detected, <0.01% = ND

MONS 043589

EXHIBIT II (1)
EPA
PCB MANUFACTURE AND SALES
MONSANTO INDUSTRIAL CHEMICALS CO.

1957 thru 1964
(Thousands of Pounds)

	1957	1958	1959	1960	1961	1962	1963	1964
U.S. PRODUCTION	(1)	(1)	(1)	37919	36515	38353	44734	50833
DOMESTIC SALES	32299	26061	31310	35214	37538	38043	38132	44869
U.S. EXPORT SALES	(2)	(2)	(2)	(2)	(2)	(2)	3647	4096
DOMESTIC SALES BY CATEGORY								
Heat Transfer	-	-	-	-	-	157	582	929
Hydraulics/Lubricants	1612	1549	2685	2523	4110	3915	3945	4374
Misc. Industrial	704	755	1569	1559	2114	1681	1528	1692
Transformer	12955	5719	5984	7921	6281	7984	7290	7997
Capacitor	17028	14099	16499	16967	15935	15382	15606	19540
Plasticizer Appl.	(1)	3939	4573	6244	9098	8924	9181	10337
Petroleum Additives	-	-	-	-	-	-	-	-
DOMESTIC SALES BY PCB GRADE								
Aroclor 1221	23	16	254	103	94	140	361	596
Aroclor 1232	196	113	240	155	241	224	13	13
Aroclor 1242	18222	10444	13598	18196	19827	20654	18510	23571
Aroclor 1248	1779	2559	3384	2827	4023	3463	5013	5238
Aroclor 1254	4461	6691	6754	6088	6294	6325	5911	6280
Aroclor 1260	7587	5982	6619	7330	6540	6595	7626	8535
Aroclor 1262	31	184	359	326	361	432	414	446
Aroclor 1268	-	72	102	189	158	210	284	190
Aroclor 1016	-	-	-	-	-	-	-	-

(1) Production figures and Plasticizer Applications figures unavailable during year indicated.
(2) U.S. Export Sales figures unavailable during year indicated. (3) Sources: References 1, 36, 37.

MONS 04390

EXHIBIT II (2)
EPA
PCB MANUFACTURE AND SALES
MONSANTO INDUSTRIAL CHEMICALS CO.

1965 thru 1972
(Thousands of Pounds)

	1965	1966	1967	1968	1969	1970	1971	1972	Est. 1973
U.S. PRODUCTION	60480	65849	75309	82854	76389	85054	34994	38600	43000
DOMESTIC SALES	51796	59078	62466	65116	67194	73061	34301	26408	36000
U.S. EXPORT SALES	4234	6852	8124	11231	10624	13651	9876	6388	5400
DOMESTIC SALES BY CATEGORY									
Heat Transfer	1237	1766	2262	2529	3050	3958	3060	752	-
Hydraulics/Lubricants	4616	4258	4643	5765	8039	7403	1552	-	-
Misc. Industrial	1841	1779	1426	1283	1079	1627	1155	-	-
Transformer	8657	8910	11071	11585	12105	13828	11134	(25676	36000
Capacitor	23749	28884	29703	29550	25022	26708	14141	(	
Plasticizer Appl.	11696	13481	13361	14404	16460	19537	3259	-	-
Petroleum Additives	-	-	-	-	1439	-	-	-	-
DOMESTIC SALES BY PCB GRADE									
Aroclor 1221	369	528	442	136	507	1476	2215	176	100
Aroclor 1232	7	16	25	90	273	260	171	-	-
Aroclor 1242	31533	39557	43055	44853	45491	48588	21981	728	1100
Aroclor 1248	5565	5015	4704	4894	5650	4073	213	807	-
Aroclor 1254	7737	7035	6696	8891	9822	12421	4661	3495	6000
Aroclor 1260	5831	5875	6417	5252	4439	4890	1725	305	-
Aroclor 1262	558	768	840	720	712	1023	1	-	-
Aroclor 1268	196	284	287	280	300	330	-	-	-
Aroclor 1016	-	-	-	-	-	-	3334	20902	29000

MONS 043591

EXHIBIT III (1)
EPA
END-USES OF AROCLORS

End-Use	1016	1221	1232	1242	1248	1254	1260	1262	1268
Sales Existing									
Capacitors	XX	X		XX past		X			
Transformers				X		XX	X past		
Sales Phased-Out									
Heat transfer				X					
Hydraulics/ lubricants									
. hydraulic fluids			X	X	X	X	X		
. vacuum pumps					X	X			
. gas-transmission turbines		X		X					
Plasticizers									
. rubbers		X	X	X	X	X			X
. synthetic resins					X	X	X	X	X
. carbonless paper				X					

MDNS 043592

(3) Nonreclaimable contaminated transformer askarels, arced askarels, askarels from manufacturing spills, and sump accumulation, etc., rich in PCBs and askarels from holding basins, drip and drain pans, washings, sample jars and containers, etc.

b. Burnable Solid Waste Material Containing PCBs. These materials can be disposed of by high-temperature incineration and consist of cellulosic materials, rags, pressboard, wood, sawdust, fuller's earth in bulk or in cloth bags, blotter papers, nitrile or cork gaskets, etc.

c. Nonburnable Solid Waste Materials Containing or Contaminated With PCBs. These materials may consist of coil structures, steel, copper, aluminum filter units of the steel mesh construction type, askarel drums, cans, etc.

Materials of this nature should be allowed to drain with the liquid collected in drip pans, etc. Further removal of adhering PCBs can be accomplished by washing or solvent extraction with kerosene or other approved washing liquids such as perchloroethylene or trichloroethylene. Accumulated liquids can be disposed of as indicated in par. F.2.a. Solid materials may be handled as normal scrap.

3. Shipment of Scrap Liquids for Disposal

All liquid scrap material should be placed in appropriate metal transport drums, properly labeled, for shipment to a company offering an acceptable disposal service.

4. Shipment of Burnable Solid Waste Material Containing PCBs for Disposable

Material of this type should be placed in open head drums with suitable closures and with the drum properly labeled for shipment to a company offering an acceptable disposal service.

5. Liquid and Solid Waste Disposal Service Organizations

a. General. Disposal of askarels and askarel-soaked materials should be accomplished by means in which there is no significant release of askarel to the environment. At present, disposal is accomplished by carefully-controlled incineration of liquids and soaked software, and by controlled landfill burial of apparatus and other hardware from which askarel has been previously drained and washed.

Present knowledge indicates that proper incineration must involve a suitable balance between dwell time and temperature in the incinerator plus oxygen availability and, finally, suitable scrubbers to remove the HCl which will be formed; e.g., (1) 2-second dwell time at 2000°F and 3 percent excess oxygen in stack gas; (2) 2 1/2-second dwell time at 2700°F and 2 percent excess oxygen in stack gas.

These facilities should meet the applicable requirements of the State in which they are located and should control effluents within the limits set forth in this document.

Controlled landfill or deep-well disposal can be used where permitted by Federal, State and local regulations.

b. Costs. In addition to the normal costs of collecting scrap liquids and solids for disposal, additional costs borne by the owner of such scrap include shipping containers, cost of transport to the disposal service organization, and a disposal fee usually based upon a per gallon or per pound charge.

c. Disposal Services. Organizations offering disposal services are listed in Section 4, including their location, facilities available, types of material handled, and disposal procedures used. Specific shipping directions, disposal procedures and costs should be obtained from the organization.

EXHIBIT VIII(19)
EPA
EXCERPTS FROM NEMA'S PROPOSED
ENVIRONMENTAL CONTROLS (continued)

II. SPECIFIC GUIDELINES

A. Transformer Manufacturers, Service Shops, - Housekeeping

It is necessary to assume that in filling equipment with askarel and during further handling of this equipment an askarel spill may occur. Therefore, it is necessary to provide facilities and a procedure for clean-up to prevent contamination.

1. Askarel Filling Area

a. The location of the askarel filling area should be adjacent to the test area and final shipping area to minimize the danger of damage of units during handling.

b. The main manufacturing area for filling equipment with askarel should be provided with impervious surface floors or suitable basins so constructed that any inadvertent leakage or spills are prevented from reaching streams, sanitary, or storm sewers. All askarel handling equipment such as pumps, hoses, etc. shall be of the askarel resistant type.

c. Drip pans shall be provided for hose connections and filling valves.

2. Special Containers for Scrap Materials

a. Drums labeled "SCRAP ASKAREL" should be available for handling all spilled and waste askarel from sumps, failed units, drip pans, sample jars, etc.

b. Open-head drums with suitable closures and labeled "SCRAP BURNABLE ASKAREL WASTE" should be available for handling contaminated cellulose insulation, rags, paper pressboard, wood, gaskets, sawdust, etc.

c. Separate containers for handling steel, copper, and aluminum, each adequately marked, shall be provided for the components of contaminated core and coil assemblies. These containers are required for the various materials when repairing or scrapping assemblies.

d. Containers for supplies of material for absorbing small askarel spills or clean-up of larger spills should be provided.

3. Conditioning of Askarels

a. Askarel Conditioning Equipment. The conditioning unit should be located either in the storage tank area or the main transformer manufacturing area for filling with askarel.

b. Fuller's Earth. Conditioning of new askarel or recycled askarel requires fuller's earth treatment. The spent fuller's earth in cartridges or bags, when replaced should be allowed to thoroughly drain over drip pans to remove as much liquid askarel as possible. The cartridge units of steel mesh construction should be placed in the "STEEL CONTAMINATED WITH ASKAREL" container for disposition. Cloth bags filled with fuller's earth should be placed in the "SCRAP BURNABLE ASKAREL WASTE" container for disposition.

4. Teardown of Units for Repair or Scrap

a. Drain all askarel from the unit either into a holding tank for reuse or into the drum labeled "SCRAP ASKAREL" for disposition, and then allow sufficient time for all of the askarel to drain from the core and coils.

b. Remove the core and coil assembly from the transformer. Sufficient absorbent material should be placed on the floor to absorb any askarel fluid that still drips from the transformer.

c. Place all materials in the appropriate salvage containers during the dismantling for later disposition.

d. All used materials, including rags, sawdust, tape, etc., regardless of quantity, shall be put into the appropriate containers for disposition.

B. Transformer Labeling

1. New Transformers

All new transformers that contain PCBs shall have a label of adequate durability permanently and prominently attached to the tank by the manufacturer, giving adequate warning and instructions.

2. In-service Transformers

The transformer manufacturer should make available suitable labels with a similar warning as shown in par. B.1 for use on existing transformers.

C. Transformer Users - Shipping, Installation, Maintenance, Sampling, Apparatus Disposal

1. General

Askarel-filled transformers are delivered to customers as sealed units from which there is no escape of askarel under normal operation. While certain types of equipment failures can permit loss of some askarel to the environment, such cases are extremely rare.

2. Transportation and Receiving

Immediately upon receipt of the equipment and following any transportation or handling accident which could affect the integrity of the tank, bushings or radiators, the transportation vehicle, tank and fittings should be examined for any leakage or spillage that may have occurred in shipping. If leakage is evident, the cause should be corrected and the spillage soaked up with absorbent materials such as sawdust, followed by a clean-up of the affected area with rags soaked with kerosene or other approved solvent such as perchloroethylene or trichloroethylene. All materials used should be collected for proper disposition as described in Section 3 Part I, par. F, "Disposal Procedures and Services."

3. Installation and Periodic Inspection

Following installation, the unit should again be inspected for any damage or leakage. It is recommended that periodic in-service inspections be made for any leaks.

4. Filling, Filtering, or Drying Askarel

Most askarel units are shipped with the proper amount of askarel but if it becomes necessary to top off a unit, the manufacturer's instructions should be followed.

If it is necessary to dry or fuller's-earth treat an askarel unit, the manufacturer's instructions should be followed. When filtering or conditioning askarel, all of the precautions previously described for drip pans, proper disposal of filter media, etc., apply.

5. Sampling

It is common practice to sample askarel from a transformer for periodic maintenance testing. As previously described, such samples should be taken in a manner to avoid any contamination of the environment. Washings should be collected for proper disposal. Field and laboratory test samples, washings, etc. should also be collected for proper disposal.

EXHIBIT VIII (23)
EPA
EXCERPTS FROM NEMA'S PROPOSED
ENVIRONMENTAL CONTROLS (continued)

6. Transformer Disposal

The ultimate disposal of an askarel-filled transformer may be accomplished in either of two ways:

a. Complete drainage and dismantling with the proper disposal of the askarel and askarel-soaked components as described earlier in Section 3, Part I, par. F, "Disposal Procedures and Services."

b. Disposition of askarel transformers by means of junk or scrap dealers should be avoided unless a transformer is first drained, followed by soaking the interior with a suitable solvent. Accumulated liquids and washings are to be disposed of as described earlier.

EXHIBIT IX (1)
EPA
* DISPOSAL SERVICES LISTED IN SECTION 4 OF NEMA'S OFFICIAL STANDARDS PROPOSAL (16)

SECTION 4
DISPOSAL SERVICES

Chem-Trol Pollution Services, Inc.
4818 Lake Avenue
Blasdell, New York 14219
Phone 716-826-5850

This organization has facilities and services capable of handling:

1. Liquids

Askarels alone or mixed with solvents or oils. Disposal by high temperature incineration.

2. Solids (Software)

Askarel-soaked compounds, rags cartons, absorbing earths, etc. Disposal by incineration or scientific landfill.

3. Solids (Hardware)

Capacitors, transformer tanks, cores, askarel-soaked metals. Disposal by scientific landfill. Has solvent extraction capability.

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* Disposal Services Listed in Section 4 Of The National Electrical Manufacturers Association (NEMA) Official Standards Proposal (16) For Handling And Disposal Of Capacitor - And Transformer - Grade Askarels Containing PCBs.

EXHIBIT IX (2)
EPA
DISPOSAL SERVICES LISTED IN SECTION 4
OF NEMA'S OFFICIAL STANDARDS PROPOSAI
(16) (continued)

Monsanto Company
800 No. Lindbergh Boulevard
St. Louis, Missouri 63166
Phone 314-694-3352

This organization has facilities and services capable of handling askarel liquids alone or mixed with other oils or solvents by high-temperature incineration. Liquid is pumped through a gun with atomizing steam into incinerator. Temperatures are maintained at 2000-2500°F with auxiliary natural gas. Exit gases are quenched to 180°F by contact with water. Gas is then passed through a high-energy venturi scrubber for removal of particulates. Before exhausting to air (110°F), gases are passed through a packed column scrubber to remove HCl.

Nuclear Engineering Company
Eastern Division
P.O. Box 146
Morehead, Kentucky 40351
Phone 606-784-6611

Disposal Division
Sheffield, Illinois
Phone 815-454-2624

This organization provides containerization, transportation and disposal services of all liquids and solids (including hardware). Disposal is in controlled chemical and scientific landfill area. AEC licensed for radioactive waste disposal. Has two West Coast locations in states of Washington and California in addition to above.

EXHIBIT IX (3)
EPA
DISPOSAL SERVICES LISTED IN SECTION 4
OF NEMA'S OFFICIAL STANDARDS PROPOSAL
(16) (continued)

Rollins-Purle, Inc.
Box 3349
Wilmington, Delaware 19899
Phone 302-478-5150

This organization has facilities and services capable of handling:

1. Liquids

Askarel alone or mixed with solvents or oils. Disposal is by high temperature incineration.

2. Solids (Software)

Askarel-soaked compounds, rags, cartons, absorbing earths, etc. Disposal is by incineration at combustion temperatures up to 2500°F. Incineration gases are scrubbed, and entrained solids removed before exhausting to air.

Disposal facilities are available at the following locations:

Logan:	Rollins-Purle, Inc. Route 322 Logan Township Bridgeport, New Jersey 08014
Baton Rouge:	Rollins-Purle, Inc. Scenic Highway & W. Cheatham Lane Scotlandville East Baton Rouge Parish Louisiana 70807
Houston:	Rollins-Purle, Inc. Tidal Road & Highway 134 Deer Park, Texas 77536

SECTION VI

MONS 043603

SECTION VI

MANUFACTURING PROCESSES IN WHICH PCBs ARE USED

In this section the end-uses of PCBs are discussed both in marketing and technical terms to define the principal channels of movement of these substances through our economy. Emphasis is placed upon the capacitor and transformer applications because currently essentially all PCBs are sold in the U.S. for these uses, and because of the reported technical problems involved in finding replacement materials. Other end-uses, for which the sole U.S. supplier has discontinued sales, are discussed in broader terms.

Based on this information, a crude accounting of PCBs' entry into the environment is developed.

1. DURING THE PERIOD FROM 1957 THROUGH 1973 (PROJECTED), ACCUMULATED U.S. CONSUMPTION OF PCBs WAS ABOUT 775 MILLION LBS., INCLUDING IMPORTS

This is based on sales of Aroclors during the same period in the U.S. and the conservative assumption that imports accounted for 2% of total domestic consumption.

Exhibit X summarizes the distribution of U.S. production during this period to the Aroclor types and principal end-uses.

(1) During The Period From 1957 Through 1973 Approximately 234 Million Lbs. Of PCBs Were Used In "Open" Systems And Approximately 541 Million Were Used In "Long Lived Contained" Systems

"Open" systems include the following end-use categories:

- hydraulics/lubricants, where losses can be relatively continuous due to leaks, maintenance problems and where make-up is required
- plasticizer applications, where PCBs can gradually evaporate from large surface areas
- miscellaneous industrial applications where PCBs occur often at low levels in widely distributed products and processes.

MONS 043604

- Of the roughly 2% of U.S. consumption that is imported only a fraction is likely to be imported in the form of or destined for open systems.

- "Long Lived Contained" systems include the following end-use categories:

  - electrical systems, capacitors and transformers which are sealed, have long service life and low failure rate

  - heat transfer equipment, where exchangers are also sealed and have relatively long life and low failure rate

- Currently essentially all PCBs sold in the U.S. are for long lived, contained electrical systems due to the voluntary restriction on sales by Monsanto.

(2) During The Period From 1957 Through 1971, Approximately 46% Of Aroclors Sold In The U.S. Were The Trichloro Or Lower Chlorobiphenyls (12)

- The trichloro and lower chlorobiphenyls are markedly less persistent in the environment than the higher homologs. See page IV-3.

- The pattern of historical end-uses in Exhibit III suggests that much of the less persistent PCBs were consumed in open systems.

- Currently the relatively low to moderately persistent Aroclor 1016 is the principal product consumed (capacitors); the moderately persistent Aroclor 1254 is purchased in appreciably lesser amounts (transformers). Small quantities of Aroclor 1221 and Aroclor 1242 are also used.

(3) An Estimate Of The Total Aroclor Used In The U.S. In Electrical Systems Since 1934 Is 752 Million Lbs.

- This is based on Boquist's (44) estimate of 690 million lbs. through 1971, adjusted for 1972 and projected 1973 consumption.

MONS 043605

- Assume conservatively that prior to 1960 the ratio was 70:30 of electrical system usage to other usage (44). This is reasonable since many of the open system applications of PCBs were promoted in the early 1960's.

- From 1960 through 1973 approximately 438 million lbs. Aroclors were consumed in electrical systems.

- Then, about 314 million lbs. Aroclors were used in electrical systems from 1934 to 1960.

. Based on the above reasoning, about 135 million lbs. Aroclors were used in applications other than electrical from 1934 to 1960.

(4) An Estimate Of The Total Aroclor Used In The U.S. In Non-Electrical Systems Since 1934 Is 367 Million Lbs.

. This is based on the 135 million lbs. estimate for the 1934 to 1960 period, and sales figures of approximately 232 million lbs. since 1960.

. Open system usage and heat-transfer applications are accounted for.

(5) An Estimate Of The Reasonable Upper Limit On Total PCB Consumption In The U.S. Since 1934 Is 1,175 Million Lbs.

. This represents 587,000 tons.

. The figure is based on the above Aroclor consumption estimates, adjusted upward by 5% for possible imports, and statistical uncertainty prior to 1957.

(6) Before 1971 There Were 10 To 15,000 Direct Purchasers of Aroclors, While Currently There Are 25-30

. These purchasers ordered Aroclors directly from Monsanto

MONS 043606

- Papageorge (36) reported that the order of magnitude of purchasers of Aroclor in 1971 or before in each end-use category is as follows:

- Heat Transfer	:	2,000
- Hydraulics	:	3,000
- Lubricants	:	"few"
- Misc. Industrial	:	"several thousand"
- Transformers and Capacitors	:	40 - 50
- Plasticizer Applications	:	2,000

- Many of these purchasers were distributors further disbursing PCBs to countless small accounts (36)

- Since Monsanto's voluntary restriction of sales and other control actions, there are currently 25-30 direct customers, all in transformer and capacitor applications. These customers use PCBs as askarels in the finished products (capacitors and transformers) or in the course of servicing.

2. 1973 USE OF PCBs BY THE U.S. ELECTRICAL INDUSTRY IS ESTIMATED AT 36 MILLION LBS. AND IS EXPECTED TO INCREASE TO ABOUT 51 MILLION LBS. BY 1978

PCBs alone or as mixtures with chlorinated benzenes are used as dielectric liquids known as Askarels, in transformers and capacitors. Besides their electrical functions, these impregnating liquids serve cooling and arc quenching functions.

Transformers are devices for converting electrical power from one voltage and current level to another, and the conducting parts of these devices must be separated from each other by a suitable insulating medium such as oils, PCBs or others.

Capacitors are devices for storing electrical energy through the physical separation of charged metal surfaces by an insulating medium.

Because of the nonflammability of PCBs, their vapors, and their arc-formed gaseous products, transformers filled with PCBs are relatively free of fire and explosion hazards and may be used in locations where failures of oil-insulated transformers would present a potential danger to life and/or property. In addition to improving the safety aspect of capacitors, PCBs also have the advantage of reliability, long life and small size.

Exhibit XI summarizes U.S. PCB sales to the electrical industry for the 1963-1973 period and estimates of 1978 sales.

(1) The Average Annual Growth Rate For PCB Use By The Electrical Industry During The 1963-1973 Period Is 4.6% And This Is Expected To Increase At About 7.4% Per Year Through 1978

PCB use in transformers has grown at the rate of 5.1% per year for the 1963-1973 period equalling the rate of growth of the value of transformer shipments shown in Exhibit XII for the same period. Industry sources (51) indicate that future PCB use will increase at a rate of about 10% per year and could account for about 19 million pounds per year of PCBs sold for transformer use by 1978.

MONS 043608

- There will be an increased demand for power and distribution transformers emanating from expansions and maintenance of the electrical utilities industry.

- Demand for specialty transformers with PCB is basically derived from industrial and commercial construction

  .. Transformers are located inside public, commercial or industrial buildings, on the roof tops of such buildings or in close proximity to such buildings.

  .. Because PCBs are used, they require no special enclosures other than that necessary to prevent accidental hazardous, mechanical or electrical contact with the equipment.

- Generation and use of electrical energy will probably be at a higher rate in the future in spite of general fuel shortages.

PCB-insulated transformers share only about 5% of the total market.

- About 125,000 such transformers have been put into service in the United States since 1932 and current production is at the rate of about 5,000 units per year (45).

  .. The amount of Askarel used in various types of transformers ranges from 40 to 500 gallons (516 to 6,450 lbs.) with an average of about 235 gallons (3,032 lbs.).

  .. The principle PCBs used are those designated as Aroclor 1254 and 1242 (54% and 42% chlorine respectively).

PCB use in capacitors has grown at a slower rate than its use in transformers and over the 1963-1973 period averaged 4.4% per year. Industry sources (50) indicate growth will be somewhat higher over the next five years amounting to about 6% annually and account for 32 million lbs. per year sold for capacitor use by 1978. Reasons given were:

MONS 043609

- Greater emphasis by lighting manufacturers to provide more controlled lighting distribution spurred on by OSHA enforcement as it pertains to illumination standards for better working conditions.

- Strong demand by new construction of industrial and commercial building.

- Greater public awareness of safety and security requirements giving impetus to more emergency lighting systems and a trend to relamp streets.

- Increased requirements for new motor and generator production for air conditioners, pumps, compressors and other general industrial and consumer equipment and appliances.

- Overall, kvar production will increase, but the total unit capacitor growth will not be equal because of improvements in capacitor design (use of polypropylene-cellulose combinations).

(2) Present Production And Handling Procedures Adopted By Major Transformer And Capacitor Manufacturers (16) Can Minimize Environmental Contamination (50).

. Specific control measures instituted by major manufacturers prevents the inadvertent loss of PCBs to the environment at all stages from initial receipt of askarel through ultimate disposal of rejected units.

- All shipments of askarel are made in closed containers such as rail tank car, truck tanks, marine or barge tanks or sealed drums.

- Transfer from shipping containers to processing systems are via closed piping, with appropriate valves, pumps, etc., provision is made for trapping and disposing of fluid lost by leakage or spills from the transfer system and from storage containers.

MONS 043610

. Capacitor manufacturing involves several additional product handling steps generating waste fluid which must be incinerated and about 5% scrap reject units which are disposed in dry-land fill sites (50).

- Metal-cellulose or metal-cellulose/polypropylene laminates are sealed in metal containers which have a weep hole at the top.

- The containers are placed in an impregnation-chamber heated under vacuum and dipped into a vat containing PCB and the PCB is sucked into the container through the weep hole.

- The capacitors are then raised and excess PCB is allowed to run off by gravity, and the weep holes are sealed by applying solder.

- The outside of the capacitors are degreased with a suitable solvent which is then disposed of by incineration.

. Exhibit XIV illustrates magnitudes of losses of PCB and disposal practices in one capacitor plant before and after controls (38). The exhibit also presents evidence that air pollution from capacitor manufacture is probably not significant (50).

(3) <u>The Capacitor And Transformer Manufacturing Industry Is A Highly Concentrated Industry</u>

. According to the National Electrical Manufacturers Association (16), its member companies have the major share of this market to the utility industry.

- 22 transformer producers
- 6 capacitor producers

. According to the Certified Ballasts Manufacturers Association (53) there are only 10 manufacturers of fluorescent lamp ballasts.

MONS 043611

- Manufacturing equipment and operating procedures safeguard against loss of askarel to the environment.

  .. Enclosure systems of sealed piping, properly gasketed joints, valves, containers and processing chambers should be used where askarel temperature may exceed 55°C.

  .. All wiper rags, clothing, waste fluids are collected and properly disposed.

- Scrap capacitors generated either during manufacture or failure in the field should be disposed of in supervised dry land-fill sites which meet State requirements.

- Askarel or askarel containing fluids can be incinerated at designated facilities. See Exhibit IX.

The flow of askarel through a typical transformer manufacturing plant is essentially a closed system (50).

- Bulk askarel, on receipt, is pumped to a storage tank.

- Askarel is transferred to the transformer filling operation (transformers can be filled directly or under vacuum) and any overflow is drained off and sent to a separate storage tank. The drained askarel is filtered through filter clay and reused.

- Transformers are then sealed, wiped clean, and shipped to customer.

Transformers that fail in the field are returned to the manufacturer or authorized repair stations (50).

- The askarel or other insulating fluid is drained and sent to approved incinerators.

- The transformer is repaired, filled with new askarel or other insulating oil under strict supervision and returned to service.

MONS 043612

(4) The Consumer Sector (Primarily Electric Utilities) Is Becoming Increasingly Conscious Of The Need To Reduce Environmental Contamination

- Industry contacts (54) indicate that steps are being taken to eliminate transformer fluids from entering plant effluent streams by building confining walls around transformer stations. While certain types of equipment failures can permit loss of some askarel to the environment, such cases are extremely rare and are limited to approximately 0.02% of the units in service per year (1,16).

- Utilities are beginning to return failed capacitors to the manufacturers, (54). Capacitor life expectancy for lighting applications is more than 10 years and more than 20 years in electrical utility applications so that losses due to in-service failure are limited to approximately 0.02% of the askarel put into service per year (1,16).

(5) The Value Of Imported Transformers In 1973 Is Estimated At 50 Million And Is A Small Portion Of Total Transformer Sales

- The annual average rate of growth of imports (current dollars) for the period 1967 - 1973 is 12.2% but comprises only 3.4% of 1973 U.S. value of shipments. See Exhibit XV.

- Sweden is the primary supplying nation to the U.S. although other supplying nations and major companies include the following:

MONS 043613

Major Foreign Companies Exporting Transformers To The U.S. (46)

Country	Firm
Britain	Ferranti-Packard Hawker-Siddely
France	Cognel
Italy	Legnano
Japan	Fuji Hitachi Mitsubishi Sumitomo Toshiba
Sweden	ASEA
Switzerland	Brown-Boveri

Probably only few imported transformers contain insulating oils due to shipping, handling and cost considerations, and the number of askarel type transformers imported is probably relatively insignificant.

MONS 043614

(6) Near Term Replacement Of PCBs In Most Askarel Electrical Applications Is Technically Not Feasible

. Although significant research effort has been, and continues to be spent, in finding replacement liquids for PCB, no substitutes have been found which provide the safety, reliability and economics of PCB.

- Mineral oil-insulated transformers can be substituted for PCB insulated transformers on a technical basis but other considerations must be taken into account (1).

  .. Safety building codes specify nonflammable oils which eliminates use of mineral oil.

  .. Serious economic constraints would occur by using insulated buses (with transformers located outdoors) and protective vaults costing $5,000 to $50,000 more per transformer if space is available (1).

- Dry-type transformers cannot be directly substituted for PCB-insulated transformers (1).

  .. Reliability of dry-types is much less showing a 7% per year failure rate compared to 0.2% for liquid-insulated units. (1).

  .. PCB-insulated transformers have a much greater overload capability and many can sustain a 100% overload for 8 hours and a 200% overload for 2 hours thus maintaining continuity of electric service during periods of temporary malfunction of related equipment (1).

  .. Some dry types are larger by 10 to 30%, putting space constraints on their use (1).

  .. Dry types are noisier by 5-10 db (1).

  .. Open dry types cannot be used in certain corrosive or hazardous atmospheres (1).

MONS 043615

Replacement of PCB use in capacitors with other liquids would have serious consequences in terms of size, reliability, failure rate and safety.

- Reverting to an oil-paper dielectric system would increase the average capacitor volume by approximately 600%, the weight by 500% and cost by 400% (44).

- The chemical, thermal and oxidative stability of PCBs in the presence of capacitor tissues and plastic films and the favorable stress distribution between solid and liquid have made it possible to design low-cost capacitors of more than 10 years life in lighting applications and more than 20 years in electric utility applications (1). First-year failure rates have been reduced to less than 0.2% (1).

- The relative nonflammability of PCBs significantly reduces the fire hazard that might otherwise accompany those failures that result in the rupture of the case.

MONS 043616

3. OPEN SYSTEMS END-USES HAVE ENCOMPASSED A BROAD RANGE OF APPLICATIONS IN WIDELY DISTRIBUTED PRODUCTS AND PROCESSES

With Monsanto's voluntary restriction of sales to capacitor and transformer applications and considering the low volume of imported PCBs, the use of these commodities in open systems has necessarily dramatically declined. Some PCB use probably still exists in these applications from past stockpiles, recycling and, in low quantities from imports. while the input of PCBs to open systems have been severely restricted suddenly, the scrapping of these materials from these sources is likely to be more gradual due to dwindling inventories and the natural decontamination of facilities.

(1) The Applicability Of PCBs In Open Systems Is Wide-Ranging

- The technology of use of PCBs in open systems and also in heat transfer is summarized in Exhibit XVI.
- In terms of PCB quantities consumed, before 1971 the decreasing order of importance of these applications was as follows:
  - plasticizers
  - hydraulics/lubricants
  - heat transfer
  - miscellaneous industrial
- Petroleum additives and pesticide extenders were experimental or short lived applications (36).

(2) In Most Open Systems Situations The Concentrations Of PCBs Associated With The Product/Process Have Probably Been Low Percentages

- Exhibit XVII presents Snell's judgments regarding PCB levels associated with various reported end-uses.
- In heat transfer and vacuum pumps pure PCBs have been used.
- The likelihood of direct contact by the general population has been significant in the carbonless paper application.

MONS 043617

- PCB levels may have been 3 to 5% in this product (5).

- Gradually declining use of PCB bearing paper can be expected as inventories are depleted and no more PCBs are used (36).

- Evidence of this is that in 1972, 95% of recycled paperboard samples examined contained less than 5 ppm PCBs. Data on the same type of material manufactured in 1970 and 1971 show that only 18% of the samples contained less than 5 ppm (3).

(3) <u>During The Next Five Years, Imports Are Expected To Be Essentially The Sole Source Of Fresh PCBs In Open System End-Uses With Investment Casting Accounting For A Major Portion</u>

. In these applications the use of PCBs are projected to be minimal compared to 1970 levels.

. Imported PCBs in finished products are expected to decline as the use and production of PCBs is reduced or eliminated in Japan and Western Europe.

. There is evidence that the Yates Manufacturing Company, Chicago, Illinois, is the principal open system importer of PCBs (55).

- the material is "Deka", decachlorobiphenyl manufactured by Caffaro (Italy)

- 500,000 lbs. may be imported annually

- about 30% Deka is used in formulating wax for investment casting

- Yates distributes to 25 customers

- an environmental control program is ready to be initiated.

MONS 043618

- .. Yates will accept spent wax from casters freight free, potentially representing about 98% of the quantities sold by Yates

- .. Yates will pretreat the recovered melt

- .. Caffaro will reprocess the recovered material

- .. The 1 1/2 to 2% wax retained in the mold can be destroyed by the castors under an oxidizing atmosphere at 1600 to 1800°F for 1 1/2 to 2 hours

- .. Yates is currently conducting long range toxicity studies

- Deka can be replaced by some benzene derivatives.

MONS 043619

EXHIBIT X
EPA
HISTORICAL DISTRIBUTION
OF PCB TYPES AND END-USE

Aroclor	U.S. Consumption of Aroclors 1957 Through 1973 (Projected) (000) Lbs.	Percent of Total
1221	7,530	1.0
1232	2,040	0.3
1242	419,810	55.3
1248	59,210	7.8
1254	115,560	15.2
1260	91,550	12.1
1262	7,220	1.0
1268	2,880	0.4
1016	53,240	7.0
Total	759,000	
End-Use Category		
Heat Transfer	20,280	2.7
Hydraulics/Lubricants	60,990	8.0
Miscellaneous Industrial	21,790	2.9
Transformer Capacitor	509,910	67.2
Plasticizer Applications	144,490	19.0
Petroleum Additives	1,440	0.2
Total	759,000	

MONS 043620

EXHIBIT XI
EPA
PCB USE IN THE ELECTRICAL INDUSTRY

U.S. Produced PCB Use In Transformers and Capacitors (1963-1978est.)
(Thousand Pounds)

Year[1]	Transformer Use	Capacitor Use	Total
1963	7,290	15,606	22,896
1964	7,997	19,540	27,537
1965	8,657	23,749	32,406
1966	8,910	28,884	37,794
1967	11,071	29,703	40,774
1968	11,585	29,550	41,135
1969	12,105	25,022	37,127
1970	13,828	26,708	40,536
1971	11,134	14,141	25,275
1972	11,310	14,366	25,676
1973(est.)	(12,000)	(24,000)	(36,000)
1978(est.)[2]	(19,320)[2]	(32,120)[2]	(51,440)[2]

1 PCB Manufacture and Sales: Monsanto Company

2 Foster D. Snell, Inc. and Industry Estimates

EXHIBIT XII
EPA
TRANSFORMER TRENDS
(1967-1974) (52)
(Million Dollars)

Year	Total Value of Shipments	Specialty Transformers	Power and Distribution Transformers	Power Regulators	Transformers n.s.k.
1967	1,134	208	790	121	15
1968	1,253	228	857	154	14
1969	1,296	271	886	128	11
1970	1,389	287	902	115	25
1971	1,344	270	903	146	26
1972	1,397	279	950	154	14
1973	1,480	295	1,010	160	15
1974(est.)	1,550	310	1,050	170	20

MONS 043622

EXHIBIT XIII
EPA
FLUORESCENT LAMP BALLAST
SHIPMENTS (1963-1972) (53)

Year	Total Shipped (1,000 units)	Value ($1,000)
1963	36,091	91,699
1964	40,841	96,364
1965	48,217	106,593
1966	51,817	130,149
1967	45,206	117,024
1968	51,102	133,027
1969	53,117	152,713
1970	50,917	163,711
1971	45,522	144,529
1972	54,980	160,740

MONS 043623

EXHIBIT XIV
EPA
PCB LOSSES IN CAPACITOR MANUFACTURE

A. MATERIAL BALANCE (38)

I. PRODUCTS

Capacitors are produced ranging in size from fluorescent lamp ballasts to 100 KVA units, with motor start units for air conditioners as the main product.

II. PCB LOSSES BEFORE CONTROLS

During 1969 the purchases of Aroclor 1242 were 3.7×10^5kg. 3.2×10^4 kg was lost in manufacture. Approximately 8.6% of Aroclor 1242 was lost. During 1969 the purchases of Aroclor 1254 were 1.5×10^4 kg. 2.3×10^3kg was lost in manufacture. Approximately 15.3% of Aroclor 1254 was lost. The losses were approximately evenly distributed between scrap from units that failed and loss in purification and degreasing operations. Some of the scrap was used as an antidusting agent in a parking lot and some mixed with a residual fuel oil and burned. No special precautions were practiced during disposal.

III. PCB LOSSES AFTER CONTROLS

During 1971 the purchases of Aroclor 1242 were 4.2×10^5 kg, and no Aroclor 1254 was purchased. Losses were reduced to 1.9×10^4 kg, or approximately 4.5%, mostly due to failures of units. All scrap fluids were disposed of by burial in sealed containers.

B. AIR EMISSIONS (50)

Sampling of ventilation stacks in one capacitor plant where Aroclor 1016 had been used for about a year showed PCB levels of about 0.03 to 0.09 ppm by volume. Five stacks were sampled, using a 10-min sampling time per hour for a 25-hr period. A detailed description of the total ventilation system was not reported. Samples of air taken 2-3 miles from the plant showed no detectable PCB levels. Sampling was done by methods suggested in the NEMA proposal (16).

EXHIBIT XV
EPA
TRANSFORMER IMPORTS

YEAR	VALUE OF IMPORTS (Million Dollars)
1967	25
1968	38
1969	40
1970	40
1971	36
1972	48
1973	50
1974 (est.)	52

EXHIBIT XVI (1)
EPA
EXCERPTS FROM BROADHURST (19) ON PCB TECHNOLOGY IN OPEN SYSTEMS AND HEAT TRANSFER

I. HYDRAULIC APPLICATIONS

Hydraulic fluids are liquids used as force transmitters.

Since most commercial hydraulic fluid mixtures are proprietary, it is difficult to obtain information with respect to their composition.

PCBs are useful in hydraulic fluids as lubricating additives in extreme pressure applications and as pour point depressants. Although it is true that the pour point of oils may be lowered by extensive dewaxing, the use of additives is much cheaper. There are other inexpensive additives which are often used for these applications and which appear to be adequate. For example, TCP (tricresyl phosphate) is chemically stable as an additive in lubricants, and, although quite toxic, it is more biodegradable than the PCBs.

An important requirement for many applications of hydraulic fluids is good heat and fire resistance. PCBs have excellent fire resistance characteristics.

Aircraft hydraulic fluids are an example of an application where excellent heat and fire resistance are necessary in view of moderately high operating temperatures and frequent accidents involving ruptured hydraulic components in the proximity of hot metallic surfaces. Also the Fiberglas acoustic blankets in the jet engines become soaked with leaking hydraulic fluid within as little as one year of use. Fire resistance in phosphate ester type hydraulic fluids has been related to PCB content. Phosphate ester hydraulic fluids have been used extensively for commercial aircraft. PCBs have been assumed to be useful as "snuffers" in that they tend to extinguish a fire supported by other constituents.

The market value of used phosphate ester type hydraulic fluids is sufficiently high that they are being recycled.

19. Broadhurst, Martin G., Use and Replaceability of Polychlorinated Biphenyls. Environmental Health Perspectives: 81-102, October 1972.

EXHIBIT XVI (2)
EPA
EXCERPTS FROM BROADHURST
(19) ON PCB TECHNOLOGY IN
OPEN SYSTEMS AND HEAT
TRANSFER (continued)

Considerable research is being done in connection with fire resistant hydraulic fluids for military aircraft Some of the hydraulic fluids being tested do not contain PCB additives, but do contain TCP. It is possible that under appropriate processing, PCBs may be replaced by TCP and perhaps certain other additives to obtain satisfactory lubrication.

It is possible that PCBs are also used in phosphate ester and other halogenated hydraulic fluids for industrial applications at high temperatures.

II. VACUUM PUMP APPLICATIONS

PCBs are used in pure form as a diffusion pump oil in commercial applications. They are useful as booster pump fluids.

Except for certain applications where alternative liquids may be incompatible with the vapors being pumped, the advantage of using PCBs in diffusion pump oils appears to be mostly an economic one. TCP is used as a commercial diffusion pump fluid and is also inexpensive. Its vapor pressure is lower than that of the PCBs making it less desirable in booster pumps, but in many applications TCP may be a suitable replacement. PCB diffusion pump oils can be decomposed after use by incineration.

III. HEAT TRANSFER APPLICATIONS

The main advantage of the PCBs as heat transfer fluids is their fire resistance. The other advantages of PCBs are low pour points and viscosities and good thermal stability up to 600°F.

Increased risk from fire and explosion is a major disadvantage with most PCB replacement fluids. Other non-flammable fluids are: 1. fluorocarbons, which have low toxicity, high thermal stability, and in spite of high cost are used as convective or evaporative coolants, 2. water, which is quite corrosive, has a high temperature limit of 374°C and requires extremely expensive high pressure systems for its use above the atmospheric boiling temperatures and 3. molten salts and metals which, because of their resistance to radiation damage, are useful in reactor applications.

EXHIBIT XVI (3)
EPA
EXCERPTS FROM BROADHURST
(19) ON PCB TECHNOLOGY IN
OPEN SYSTEMS AND HEAT
TRANSFER (continued)

Several liquids are more stable at high temperatures than the PCBs. Few of these liquids are non-flammable. The phosphate esters, silanes, and aromatic ethers have high fire points (around 600°F), but they are flammable and it is not clear how high the fire point must be for a fluid to be safe in a high temperature system, especially in the event of leakage into a furnace. The details of specific heat transfer applications are necessary to evaluate the suitability of PCB replacement fluids.

IV. PLASTICIZER APPLICATIONS

PCBs are attractive as plasticizers because of their high compatability factor. The PCBs are permanently thermoplastic, chemically stable, non-oxidizing, non-corrosive, have excellent solvating powers, and are fire resistant. They are not normally attacked by acids, alkalies, or water. They are insoluble in water, glycerol, and glycols, and are soluble in organic solvents.

V. ADHESIVES APPLICATIONS

The more resinous chlorinated polyphenyls can be included in this category. Hot melt adhesive compositions based on phenolic resins are used in brake linings, clutch faces, and grinding wheels. Chlorinated polyphenyls and aryl phosphates (non-reactive plasticizers) also improve flow properties of phenolic resins prior to curing as well as imparting some flame proofing characteristics to the composition. PCBs have also been used in laminating adhesive formulations involving polyurethanes and polycarbonates to prepare safety and acoustical glasses.

Polyarylene sulfides, treated with chlorinated biphenyls, are employed to laminate ceramics and metals. An ethylene-propylene copolymer blended with PCB has been used in a hot melt adhesive having improved toughness and resistance to oxidative and thermal degradation. It has excellent adhesion to polyethylene films. Similar adhesives, used to bond polyethylene to itself or other plastics, were prepared from styrene, alpha-methylstyrene or methylmethacrylate. Washable wall coverings and upholstering materials, made from films of polyvinyl chloride, are claimed to be improved by the addition of PCB to the adhesive formulation. PCBs can also be applied in the preparation of polyvinyl alcohol adhesive compositions which are used to manufacture envelopes, in self-adhering films and in preparation of coatings of pressure-rupturable capsules for adhesive tape.

EXHIBIT XVI (4)
EPA
EXCERPTS FROM BROADHURST
(19) ON PCB TECHNOLOGY IN
OPEN SYSTEMS AND HEAT
TRANSFER (continued)

VI. TEXTILE COATINGS APPLICATIONS

A textile coating for ironing board covers can be formed from a mixture of chlorinated biphenyl, cellulose acetobutyrate, and aluminum metal particles. PCBs also can be used as a de-lustering agent for rayons. Poly-alpha-olefins, (i. e., polypropylene) films, when coated with a mixture of PCBs, UV light absorbers, and antioxidants show increased stabilization to oxidative degradation on exposure to sunlight and weathering. Polyamide (nylon-type) yarns were found to be flame proofed when treated with PCB. Chlorinated biphenyls can also be used as ingredients in some sealing formulations employed to waterproof canvas.

VII. SURFACE COATINGS APPLICATIONS

In paints and varnishes, the hard resinous PCBs impart increased hardness to films, and the softer resins give flexibility. In nitrocellulose lacquers, PCBs either alone or in combination with other plasticizers and resins impart increased weatherability, luster, adhesion, and decreased burning rates.

PCB and other plasticizers can be used in combination with poly (organo-siloxanes) to prepare film casting solutions. These polymeric films could be employed in electrical coatings, insulating tapes, and protective lacquers.

Plastic vessels, i. e. bottles, manufactured from polyethylene, polyvinyl chloride, polyvinylidene chloride or similar resins coated with an epoxy lacquer (which contains PCB) make the vessels pliant, impervious, and resistant to aromas, acids, and alkalis.

Paints at atomic energy installations are needed for (a) contaminated area (b) tolerance to high energy radiation, and (c) to meet clean condition standards. Paints for (a) should be glossy and smooth and should not transmit contaminants. For this purpose, the vinyl polymers are preferred over epoxy lacquers. The best plasticizers for use in this area are claimed to be the PCBs. The extent, if any, of their use in this application is unknown.

The PCBs are usually compatible with epoxy resins, and they give good final hardness and impact resistance equal to the unmodified resin. They also aid in the acceptance by the resin of larger amounts of fillers. Epoxy resins in combination with PCB can be used as protective coatings for metals, i. e., encapsulating electrical capacitors, for ferrite magnet cores, for corrosion resistant resistors, for pigmented metal coatings for winter camouflage coatings, and for pipes and blocks.

EXHIBIT XVI (5)
EPA
EXCERPTS FROM BROADHURST
(19) ON PCB TECHNOLOGY IN
OPEN SYSTEMS AND HEAT
TRANSFER (continued)

VIII. SEALANTS APPLICATIONS

PCBs can be used as plasticizers in the formulation of putties from copolymers or ethylene-vinyl acetate or styrene. The products are non-hardening, and resistant to moisture and frost and show good weatherability. A non-sticky, non-hardening putty was also prepared from polysulfide mixtures which employs PCB as the plasticizer. This putty gave good bonding to building materials and had good extrudability and shape retention. Elastic pavement or concrete sealing compositions, used for traffic markings, were prepared from coal-tar-polysulfide mixtures which are plasticized with PCB. A sealant, effective for concrete and asphalt applications, can be formulated from a mixture of polysulfide, chlorinated rubber, and polyisocyanate, and plasticized with PCB.

IX. PRINTING APPLICATIONS

Chlorinated biphenyls have been employed as part of the formulations used to prepare pressure-sensitive record and colored copying papers. They have been used to coat papers used in thermographic duplicating processes as well as in xerographic transfer processes. Solvent-free printing on polyolefin plastics can be accomplished by heating a mixture of low molecular weight material, chlorinated biphenyl or terpene resin, and suitable pigments and dyes. Printing plates can be prepared from compositions containing a liquid resin such as epoxy, polyester, urethane, acrylic or vinyl with an excess of curing agent and PCB as the plasticizer. The extent, if any, of current uses of PCBs in printing application is unknown.

X. FIRE RETARDANT AND FLAME-PROOFING APPLICATIONS

For increased effectiveness in flame retardant applications, the PCBs can be admixed with various metal oxides. Some flame retardant compositions based upon these mixtures are used in: polyolefin yarns; organopolysiloxane sealants: thermoplastic poly; fireproof panels made from starch which can be used for doors, floors, ceilings, and partitions; polyamides; and in fireproof fiberboards.

XI. MISCELLANEOUS APPLICATIONS

- Catalyst carrier for polymerization of olefins.

EXHIBIT XVI (6)
EPA
EXCERPTS FROM BROADHURST (19) ON PCB TECHNOLOGY IN OPEN SYSTEMS AND HEAT TRANSFER (continued)

- Conversion of water-permeable soil to a non-permeable state. Soil is made non-permeable by applying to the soil a composition consisting of an ethoxylene-based resin, polyamide, camphor, and PCB as plasticizer. The composition has a density greater than water, and it hardens under water. It can be applied to river banks, where it flows down the bank, and after hardening, prevents penetration of water (soil erosion-retardant).

- Combined insecticide and bactericide formulations. The composition contains aldrin or dieldrin, naphthalene hydrocarbons, malathion, methoxychlor, lindane, chlordane, terpineol, and chlorinated biphenyl as active agents.

- Inhibitors of microbial growth in enamel clay formulations.

- Plastic sound insulating materials for railway cars.

- Plastic (PVC) decorative articles which give the impression of internal scintillation.

- Increasing the density of carbon plates by impregnation with PCB.

- Graphite electrodes with low thermal expansion coefficients and high bending strengths.

- Increasing the coke yield from coal pitch. The coke is very hard, dark, and brilliant.

- As a metal quencher or tempering agent for steel, alloys, and glass.

- As an aid to fusion cutting of stacked metallic plates without adherence. The cutting is done with an electric arc or oxy-gas torch.

EXHIBIT XVII
EPA
PCB LEVELS ASSOCIATED WITH
VARIOUS PRODUCTS/PROCESSES

Reported Applications	PCB Levels, Percent Ranges				Likelihood of Direct Contact by the General Population
	Trace	Low	Medium	High	Pure Form	
. Hydraulic		X				Low
. Vacuum pumps					X	Low
. Heat transfer					X	Low
. Plasticizers		X				Medium
. Adhesives		X				Medium
. Textile coatings		X				Medium
. Surface coatings		X				Medium
. Sealants		X				Medium
. Printing		X				Low
. Fire retardants and flame proofing		X				Medium
. Carbonless copy paper		X				High

MONS 043632

SECTION VII

SECTION VII

THE ENTRY OF PCBs INTO THE ENVIRONMENT AND MANAGEMENT STEPS

In this section the input/output dynamics of PCB consumption in the major end-use categories are examined. Patterns of entry into the environment are defined. Environmental control actions are summarized, and criteria for further management steps are developed.

1. ABOUT 500 MILLION LBS. OF PCBs ARE IN-SERVICE, BASED ON A SNELL LIFE CYCLE MODEL

Rough models of the entry of PCBs into the environment from both open and long-lived contained systems have been developed, notably by Nisbet and Sarofim (13). Continuation of this work has been published by Nelson (38).

(1) Nelson (38) Estimated That The Equivalent of 80% of The Annual Aroclor Sales Was Scrapped In 1970

- During 1970 about 58 million lbs. of PCBs became scrap (80% of 73 million lbs., the 1970 domestic sales of Aroclors).
- Nelson (38) distributed this scrappage to principal routes of environmental entry as follows:
  - 2 to 4 million lbs. lost to the atmosphere through evaporation from plasticizer applications
  - 8 to 10 million lbs. attributed to leaks and disposal of hydraulic, heat exchange and transformer fluids, mostly entering coastal and fresh waters

MONS 043634

- about 44 million lbs. attributed to disposal in dumps and landfills in capacitors, plastics and miscellaneous products; Nelson (38) further distributed this solid waste portion as follows:

  .. 10-20% burned, at various efficiencies and possibly in conjunction with the production of highly toxic by-products such as dichlorobiphenyl furanes and dioxanes

  .. about 2% vaporized

  .. long-term environmental storage of the remaining 34 to 39 million lbs. of PCBs in solid wastes in dumps and landfills

Based on correlation of Aroclor type with principal end-use as well as pattern of scrappage, Nelson (38) postulated that prior to Monsanto's elimination of sales for open system applications

- PCBs entering the environment through the air route have been most likely Aroclors 1248 through 1260 from plastics and Aroclor 1242 from burning of refuse containing capacitors.

- PCBs entering the environment through the water route have been most likely Aroclors 1242 through 1260 from hydraulic, lubricant and transformer applications.

- PCBs stored in the environment in dumps and landfills have been most likely Aroclor 1242 from capacitors.

MONS 043635

(2) A Life Cycle Model, Developed From Further Evaluation Of Nelson's (38) Assumptions Regarding The Scrappage Rates Of PCBs, Indicates That The Equivalent Of Only About 26% Of The Annual Aroclor Sales Was Scrapped In 1970

. The PCB service life functions in Exhibit XVIII are the basis of the Snell model.

- These functions disaggregate annual usage.

- Each major end-use category is characterized in terms of

  .. PCB scrappage as percent of annual sales

  .. corresponding approximate in-service life of PCB

. Assuming that in-service lives of PCBs in the major end-uses have been and will be reasonably constant, the following information can be generated

- estimates of the total amount of PCBs in-service, based on annual sales figures

- estimates of the amount of PCBs scrapped as a function of time and through the principal channels of entry into the environment, especially where a channel is characteristic of an end-use category

- projection of the disappearance of the current open-system inventory of PCBs in-service

- testing the consequences of various PCB control scenarios after further refinement of the model

MONS 043636

. During 1970 about 19 million lbs. of PCBs became scrap using the Snell model, corresponding to about 26% of the annual Aroclor sales. (Nelson (38) estimated that these figures were 58 million lbs. and 80%, respectively). Entry into the environment probably followed the pattern defined by Nelson (38), presented in summary form under 1. (1) above.

- 2 to 4 million lbs. to air
- about 3 million lbs. to water
- 12 to 14 million lbs. to land

.. roughly 20% burned

.. roughly 80% in long term environmental storage in dumps and landfills

. The total amount of PCBs in-service through the end of 1973 was estimated using the procedure exemplified in Exhibit XIX. The table below presents in-service estimates by end-use category.

End-Use	PCB Quantity In-Service Through 1973 (million lbs.)
Transformers	205
Capacitors	270
Heat exchangers	11
Plasticizer applications	insignificant
Hydraulic fluids and lubricants	9
Miscellaneous industrial applications	insignificant
Total	495

. Assuming continuation of the current pattern of Aroclor sales through 1978, at the end of the next five years essentially no PCBs will be in non-electrical service

. Minimizing environmental burden from the roughly 20 million lbs. of PCBs still in non-electrical service is probably unfeasible logistically

. Exhibit XX summarizes the historical pattern of PCB channels to the environment.

MONS 043637

2. SIGNIFICANT STEPS HAVE ALREADY BEEN TAKEN TO ENVIRONMENTALLY MANAGE PCBs IN PRODUCTION, CONSUMPTION AND COMMERCE

Major control actions and strategy considerations are summarized below.

(1) The Monsanto Company, The Sole U.S. Producer, Has Led Environmental Control of PCBs

. These steps fall into the general categories of process control, product improvement, sales restrictions, establishment of a waste disposal service, and "good will".

. Principal reported environmental controls at the existing production facility are summarized in Section V, and in Exhibit V.

. Product improvement is represented by Aroclor 1016, a variant of Aroclor 1242 and its replacement in new capacitors. The 1016 material contains a typical concentration of 0.4% by weight of the higher boiling (more persistent) chlorobiphenyl homologs, whereas the 1242 product contained about 7% of these (16). R&D efforts to find or develop equivalent, but readily biodegradable replacements for Aroclors in electrical service have not been successful (36).

. Sales restrictions include:

- discontinuation of sales to end-uses other than capacitors and transformers (long-lived closed systems)

- restriction on sales to non-electrical manufacturers (36)

- requirement of a letter of intent by purchasers to follow good manufacturing practices (36).

- The waste disposal service includes destruction of waste PCB liquids in the incinerator described in Section V and the acceptance of used containers for controlled recycle. The following are key features of the container recycling service

  - acceptance by Monsanto
  - decontamination by an affiliated contractor
  - firing of containers
  - refurbishing for resale for non-food uses
  - incineration by Monsanto of the decontamination solvents

- "Good will" includes general cooperativeness and an organizational awareness of product acceptability and stewardship.

  - As a service to open system customers, the firm has prepared a list of possible replacements for PCBs in adhesives and coatings (14).
  - The company has set up an educational program for customers, showing means for avoiding losses during the handling and use of PCBs (14).

(2) <u>The Market Statistics Suggest That The Great Majority Of Open System Users Of PCBs Have Found Alternatives To This Commodity, But There Has Not Been A Sense Of Urgency To Eliminate PCBs Already In Service</u>

- Countless PCB bearing "open" processes and products currently in use, pre-date the voluntary elimination of sales to open system customers by Monsanto.

  - With time, PCBs from these sources will disappear from active usage. This will lead to a corresponding gradual lessening in environmental burden

MONS 043639

- There may be appreciable quantities of carbonless copy paper with PCBs in widely distributed, albeit gradually declining inventories (36)

- The literature and limited interviews indicate that there has not been a sense of urgency on the part of users for the controlled replacement of PCB fluids in non-food processing

. The same sources also indicate that PCBs were not handled with greater care in processing than other plasticizers, or analogous materials in the various end-uses

  - open system formulation and processing facilities may be still contaminated with PCBs from past practice

  - a limited number of facilities may still be processing PCBs from past inventories or imports

  - it is reasonable to assume that the general environment of industrial areas will be burdened with a gradually declining input of PCBs from discontinued past practices

(3) <u>The Current Buyers Of PCBs For Capacitor And Transformer Insulation Have Taken Formal Steps Toward Environmental Control</u>

. A number of purchasers have discontinued the use of these materials (51), including

  - Allis Chalmers
  - Wagner Electric
  - Esco Manufacturing
  - Others

MONS 043640

- Manufacturers through their industry association, the National Association of Electrical Manufacturers (NEMA), have developed the "Proposed American National Standard Guidelines For Handling and Disposal Of Capacitor - And Transformer-Grade Askarels Containing Polychlorinated Biphenyls, C107.1 - ( ) (16).

  - See Exhibits VIII and IX for excerpts of the principal proposed technical procedures

  - The prime users of askarel capacitors and transformers were represented by an industry delegation, coordinated by the Edison Electric Institute (43)

- Nelson (38) reported a case study of environmental losses at a capacitor manufacturing facility before and after controls were instituted. See Exhibit XIV. The major sources of PCB losses were

  - Aroclor handling and filtration
  - capacitor degreasing
  - capacitor rejection

- Although askarel capacitors are long-lived closed systems, in use these are universally distributed.

  - the feasibility of PCB control in capacitor manufacture can depend on whether or not best available environmental controls for organic chemicals of the same general class are sufficient

  - PCB control at the point of capacitor use could represent complex logistics, but the requirement of "turning in" faulty or useless capacitors for central disposal (as in exchange for replacement capacitors) could be workable

  - the feasibility of PCB control in the capacitor disposal phase can depend on

    .. whether or not conventional (landfill or other) solid waste disposal practices are suitable

MONS 043641

- .. the extent to which improper disposal practices, such as poorly controlled burning of capacitors, are significant and can be controlled

. The environmental control of askarel transformers is less complex than that of capacitors

  - the number of transformers manufactured annually and already installed is significantly less than the number of capacitors

  - PCB control during transformer manufacture is less complex than that during capacitor manufacture because the former is a simpler process

  - PCB control during transformer use is expected to be practicable because users are overwhelmingly industrial, concentrated in the electrical industry and in numbers that can be "traced"

  - PCB control in the transformer or waste askarel disposal phase is expected to be feasible for the same reasons

. It has been estimated that the future environmental losses of PCBs from electrical applications can be held below 0.03% of the PCBs in-service (44) with proper control of scraps.

  - small losses from product failure in-service would occur

  - with time, an increasing portion of askarels will be Aroclor 1016. This will minimize the entry into the environment of the more persistent homologs of PCB.

(4) <u>The Control Of PCBs Already In The Environment Is Not Feasible, Except In Highly Localized Situations</u>

. PCBs are universally distributed in the environment, with reported higher concentrations near industrial areas (28).

MONS 043642

- Highly localized situations may include
  - landfills and open dumps
  - some contaminated production facilities (discontinued or on-going production)
  - spill sites
  - some sludges
- While appreciable decontamination activities in the general environment are not feasible, monitoring can indicate hazard as well as record dissipation of PCBs to acceptable levels.

(5) Regulatory Action Can Assure Highly Controlled Use Of PCBs In The Future

- One alternative is to simply ban the production and remaining uses of PCBs in the U.S., as in Japan, where need for exemptions has arisen. The economic impact of such action should be thoroughly investigated, considering the technological and institutional dependence in the U.S. on askarel type capacitors and transformers
- Another alternative is to establish specific controls such as
  - the Food and Drug Administration's actions to prevent PCBs contamination of animal feed, foods, and food packaging materials
  - the Environmental Protection Agency's actions to include PCBs on the Toxic Substances List and to promulgate Toxic Effluent Guidelines
  - the actions of the U.S. Customs Bureau to monitor PCB imports
  - the actions of the Occupational Safety and Health Administration to limit worker exposures to PCBs

- the actions of the Organization for Economic Cooperation and Development to limit international use of PCBs

  .. through exchange of statistical data

  .. through controls on production; distribution, imports/exports

  .. through controls on end-uses, such as limitation to electrical and other systems where non-flammability is essential

A logical regulatory extension of the pattern of recent voluntary controls is

- formal banning of the sale or purchase of PCBs for non-electrical uses, and the granting of exemptions on a case-by-case basis

- formal sanctioning of the National Standard Guidelines For Handling and Disposal of Capacitor - And Transformer - Grade Askarels Containing Polychlorinated Biphenyls

- establishing an enforcement mechanism that also applies to importing of PCBs

MONS 043644

EXHIBIT XVIII
EPA
PCB SERVICE LIFE FUNCTIONS

Historical PCB End-Use Category	Annual Sales Outlook	Historical PCB Scrappage As Percent of Annual Sales	Corresponding In-Service Life of PCBs, Years	Remarks
. Transformers	10% growth	3 - 4%	30	Askarel transformers have 30 year or longer lifetime (45, 54)
. Capacitors	6% growth	8%	12	Capacitors life in electric utility service is about 20 years (45). This is about 10 years in lighting use (45). Capacitors are sometimes scrapped as part of the parent product, such as lamp ballasts.
. Heat exchangers	No sales	20%	5	
. Plasticizer applications	No sales	60%	1.7	Roughly 15% vaporization is considered during service life (48). Plastics have a short useful life.
. Hydraulic fluids and lubricants	No sales	25%	4	In 1968 about 30% of the annual usage of industrial lubricating oils and about 20% of the annual usage of hydraulic fluids were waste (49)
Miscellaneous industrial applications	No sales	90%	1.1	

MONS 043645

EXHIBIT XIX
EPA
EXAMPLE OF THE USE OF PCB SERVICE LIFE FUNCTIONS: ESTIMATE OF CAPACITOR PCBs IN-SERVICE

- The in-service life of PCBs in capacitors is estimated to be about 12 years, overall. See Exhibit XVIII.

- The table below presents Aroclor sales during the last 12 years for capacitor applications.

Year	Sales of Capacitor Aroclors, Million Lbs.
1973	24.0
1972	17.1
1971	14.1
1970	26.7
1969	25.0
1968	29.6
1967	29.7
1966	28.9
1965	23.7
1964	19.5
1963	15.6
1962	15.4
	270

- Roughly 270 million lbs. of PCBs are in capacitor service through the end of 1973.

- Refined estimates could be obtained through consideration of the typical life cycles of the different types of askarel capacitors with corresponding disaggregation of Aroclor sales data.

MONS 043646

EXHIBIT XX
EPA
HISTORICAL PATTERN OF PCB
CHANNELS TO THE ENVIRONMENT

Historical PCB End-Use Category	Interface With The Environment Of Scrap PCBs		
	Air	Water	Land (dumps, landfills, etc.)
. Transformers	X	XX	XX
. Capacitors	X		XXX
. Heat exchangers	X	XXX	X
. Plasticizer applications	XX		XXX
. Hydraulic fluids and lubricants	X	XX	XX
. Miscellaneous industrial applications	X		XXX
. All categories: ratio of importance based on Nisbet and Sarofim's work (9)	1	2	10

Note: XXX = Principal channel; XX = secondary channel; X = non-negligible channel

MONS 043647

SECTION VIII

MONS 043648

SECTION VIII

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MONS 043653

2. Liquid

Operating procedures should be such as to minimize or eliminate contact with askarels. Use of eye protection is recommended. The use of porous gloves which can absorb and retain askarels is to be avoided. Barrier creams or resistant gloves should be used if contact is unavoidable. Use of enclosed transfer and handling equipment, processing equipment, and mechanical washers reduces direct contact.

Safety glasses with side shields or a face shield should be worn when handling askarels.

D. Manufacturing Housekeeping

Manufacturing equipment and operating procedures should safeguard against loss of askarels to the environment through proper containment and disposal procedures.

Enclosed systems of sealed piping, properly gasketed joints, valves, containers, and processing chambers should be used for any portion of the operation where askarel temperatures may exceed 55°C. Enclosure should preferably extend to all other portions of the system insofar as practicable.

Containment provisions should be established around all askarel processing areas to ensure against inadvertent loss to sewer systems by spillage, leakage, or other uncontrolled conditions or events.

Spills of askarel should be removed promptly by means of absorptive material, such as sawdust, or trapped and removed by pumping or other suitable means.

Waste fluids containing askarel not suitable for reconditioning or reuse should be collected (by means of traps, drip pans, trays, etc.) from the various parts of the manufacturing and processing area (including washers or other cleaning devices). Disposal should be made in accordance with Part V of this section.

Wiper rags, clothing and other extraneous materials saturated with askarels should be collected within the containment area for properly controlled laundering or disposal (see Part V of this section).

E. Disposal of Askarel Wastes

Methods for disposal of liquids and saturated solids generated by the manufacturing operation should be in accordance with those outlined in Part V of this section and should include (but not be limited to) the following wastes:

1. Contaminated liquid askarel which is unsuitable for reclaiming as a dielectric fluid.

2. Liquid askarel from solvent operations or water/ detergent type washers.

3. Saturated earth or other absorbent media from filtering operations.

4. Saturated sawdust or other absorptive materials from spills.

5. Saturated filters from vapor control devices and other filters.

6. Saturated wastes (paper, rags, etc.).

7. Saturated, spent gasket materials.

8. Askarel-contaminated vacuum pump oils.

9. Askarel-contaminated steam jet vacuum system condensates.

F. Miscellaneous Procedures

1. Spills by leakage from finished capacitors should be cleaned up promptly by means of absorbent media which should then be moved to containers provided for that purpose within the containment area and later disposed of properly.

EXHIBIT VIII(6)
EPA
EXCERPTS FROM NEMA'S PROPOSED
ENVIRONMENTAL CONTROLS (continued)

2. Askarel wastes should never be disposed of down effluent drains or sewers. The utmost care must be exercised to prevent accidental loss by these avenues to the environment.

3. Capacitors failing tests or otherwise designated for disposal must be controlled and handled in accordance with the intent of the procedures above, finally being disposed of by one of the means outlined in Part V of this section.

EXHIBIT VIII(7)
EPA
EXCERPTS FROM NEMA'S PROPOSED
ENVIRONMENTAL CONTROLS (continued)

IV. CONTROL OF WATER EFFLUENTS

...Existing drain systems in capacitor manufacturing plants are probably contaminated as a result of past practices, and askarel traces may continue to show up in effluent streams for some time. However, the level should continue to decrease with the proper containment of askarel wastes and no further discharges into drain systems. Other sections of this report provide that no askarel wastes of any kind be disposed of in any water effluent streams and that accidental spills be prevented from getting into such streams.

A. Concentration Limits

The 1972 EPA proposals are to keep PCB levels in rivers and lakes below 0.01 parts per billion. Plant effluent streams should be managed and controlled in a manner consistent with this goal.

B. Monitoring Streams

On a regular basis consistent with plant situations, all effluent streams should be analyzed. The procedures for performing the necessary analyses are contained in Section 5, Analysis of Water and Sediment for Polychlorinated Biphenyls. This procedure or its equivalent should be used.

C. Methods For Minimizing Effluent Stream Contamination

The ideal approach is to totally isolate all effluent streams that could be contaminated with askarels during manufacturing processes and prevent them from being discharged from the plant. Carbon adsorption, limestone beds, and solvent extraction are techniques which can be applied to reduce the askarel content of effluent streams. These techniques may be most useful in cleaning up water used in plant processing and to permit recycling.

V. SCRAP DISPOSAL PROCEDURES

The manufacture and use of capacitors involve processes which produce askarel-saturated solids and liquids containing or composed entirely of askarel, which should be disposed of as wastes. Specific sources of these materials appear throughout this document but may be placed into three categories:

1. Capacitor units impregnated with askarel, production and field rejects.

2. Manufacturing process liquid wastes containing askarel.

3. Solid waste purposely or accidently saturated with askarel.

Disposal should be done in a manner which is consistent with proper concern for the environment and which minimizes any release of askarels to the environment.

A. Disposal of Capacitor Units

Scrap capacitor units can be generated during manufacturing processes or during field service.

Production rejects are those capacitors which are rejected after the impregnation process in the course of production by the capacitor manufacturer. They may be rejected for mechanical or electrical reasons, or because of obsolescence.

Field rejects are those units which are rejected or which, for other reasons, are to be scrapped after shipment from the plant where they were manufactured.

EXHIBIT VIII (9)
EPA
EXCERPTS FROM NEMA'S PROPOSED
ENVIRONMENTAL CONTROLS (continued)

1. Production Rejects

Rejected capacitors in capacitor manufacturing plants represent a concentration of askarel. It is important that their disposition be made in a manner consistent with proper concern for the environment. Therefore, capacitors should be disposed of only in supervised dry landfill sites which meet all applicable State requirements.

Care should be exercised to insure that no loss of liquid will occur during transportation to the disposal site.

Incineration of scrap capacitors in facilities designed to accept such solids should provide an alternate means of disposal as such services become available in the future.

2. Field Rejects

Small capacitors (defined as containing less than 2 pounds of askarel) are practically always used as components in other electrical or electromechanical equipment. Typical examples of large quantity usage of such capacitors are in fluorescent lamp ballasts and residential air conditioning equipment. Failure of such capacitors may result in scrapping of the device of which it is a part (as in a fluorescent ballast) or replacement and scrapping of the individual capacitor (as in a room air conditioner). However, the majority of such capacitors do not fail in service, but are scrapped as a result of wearing out or obsolescence of the devices in which the capacitors are used as components. Thus, the matter of disposal is characterized by a low concentration of small quantities of askarel throughout the country and, indeed, throughout the world. Fortunately, the nature of the devices and equipment in which such capacitors are used is such that they are normally disposed of in dry landfills as a matter of convenience. Since it is impractical at present to exercise any meaningful control over the disposition of the bulk of such devices and equipment, it is imperative that askarel used for impregnating small capacitors be limited to the recently introduced type which contains a typical concentration of 0.4 percent of the higher boiling homologs.*

* Monsanto Method T-02302

Large capacitors (those incorporating more than 2 pounds of askarel) should be disposed of according to the procedure for production rejects. See par. A.1.

B. Disposal of Liquid Wastes

All waste askarel or liquid wastes containing askarel should be disposed of in accordance with one of the following procedures:

1. Incineration

Present knowledge indicates that proper incineration must involve a suitable balance between dwell time and temperature in the incinerator plus oxygen availability and, finally, suitable scrubbers to remove the HCl which will be formed; e.g., (1) 2-second dwell time at 2000°F and 3 percent excess oxygen in stack gas; (2) 1 1/2-second dwell time at 2700°F and 2 percent excess oxygen in stack gas.

These facilities should meet the applicable requirements of the State in which they are located and should control effluents within the limits set forth in this document.

2. Toxic and Hazardous Waste Disposal Sites

Certain landfill sites have been classified by State and Federal Governments as suitable for the disposal of toxic and hazardous liquids. Where such approved sites exist, they may be used for the disposal of liquid wastes described in this document. (See Section 4).

3. Packaging and Shipment

a. Transportation to the disposal facility should be in containers which will prevent leakage and accidental loss of askarel to the environment.

b. Containers should be labeled as to contents and precautions relative to loss to the environment.

c. Containers used for this purpose should not be used for any other materials or retired from service until they are completely cleaned. Any solvents used in cleaning these containers will be contaminated with askarel and should be disposed of according to the same procedures herein described.

C. Disposal of Solid Wastes

All solid wastes which have been saturated with askarel should be disposed of by the following procedure:

1. The saturated wastes should be placed into leak-proof containers and transported to a supervised dry landfill site meeting State requirements. Alternatively, they can be disposed of by incineration in State-approved facilities.

2. Solid absorbents used for spills can be disposed of uncontained in the supervised dry landfill site; transport to the site should be in closed containers. Alternatively, incineration can be used in accordance with par. B (See Section 4 for facilities).

VI. LABELING

Capacitor units vary greatly in size and in end use or application. Small capacitor units are frequently applied as a component of another piece of equipment such as a fluorescent lighting ballast, a roadway or area lighting luminaire; a motor, etc. In such applications a label on the capacitor unit referencing approved disposal procedure would not normally be visible when the piece of equipment is disposed of.

For the foregoing reasons the method of providing disposal instructions for small capacitors and large capacitors is treated separately.

1. Small Units (incorporating Less Than 2 Pounds of Askarel)

Small capacitors are defined as those which contain askarel in quantities up to about two (2) pounds each and in which the free liquid does not exceed 0.4 pounds. They are hermetically sealed in metallic cases. Such capacitors are applied as a component of a larger piece of equipment. Attaching a label to such equipment referencing this Guideline or describing disposal procedures would be of limited practical value.

2. Large Capacitor Units (Incorporating More Than 2 Pounds of Askarel)

The capacitor manufacturer should affix a label in a conspicuous place, referencing this document or describing disposal procedures consistent with it.

SECTION 3
TRANSFORMER GUIDELINES

I. GENERAL GUIDELINES

A. Definitions - Types of Transformer Askarels

The term askarel generally describes a broad class of non-flammable synthetic chlorinated hydrocarbon insulating liquids widely used in transformers, reactors, and accessory equipment operated at power frequencies. Askarels of various compositional types are in use (for the general properties and types, see ASTM Specification for Chlorinated Aromatic Hydrocarbons (Askarels) for Transformers, D 2283).

The following trademarks are used by electrical manufacturers to designate the askarels used in their products:

- Asbestol
- Chlorextol
- Inerteen
- No-Flamol
- Pyranol
- Saf-T-Kuhl

B. Safety Precautions

1. Vapors

Breathing vapor or fumes from heated askarels should be avoided. Provisions shall be made for adequate ventilation and regulation of manufacturing operations to avoid open exposure of hot askarels (55C or higher). The gases produced when askarel is decomposed by very high temperatures (such as that of an electric arc) in the presence of air or organic

insulating materials contain a high percentage of hydrogen chloride, and small percentages of other gases. If exposure to high concentrations of askarels or its arced products is necessary under emergency conditions, an approved gas mask of the organic canister-type or self-contained breathing apparatus must be worn. Such exposure should be under the surveillance of other personnel capable of rescue in case of accident. If the odor of askarel or its arced products is detected by the person wearing protective equipment, he should immediately go into fresh air.

2. Liquid

Operating procedures should require avoidance of contact with any askarels. The use of porous gloves which can absorb and retain askarels is to be avoided. Resistant gloves and aprons of the neoprene, polyethylene, viton type should be used if contact is unavoidable. In case of spillage on the clothing, the clothing should be removed as soon as practical, the skin washed and the clothing laundered.

Safety glasses with side shields or a face shield should be worn when handling askarels.

Hands should be washed with warm water and soap before eating, drinking, smoking or using toilet facilities.

C. Transport Container Marking

Any container such as tank cars, tank trucks, drums, cans, etc., used to transport transformer askarels, new or used, should be labeled ...

D. Receiving, Handling and Storage of Askarels

Askarels are shipped in tank cars, tank trucks, steel drums, metal cans and test sample containers. When received, all containers should be inspected for leaks.

1. Storage Tanks

Storage tanks should be erected so that inspection can be made for leaks or spills. Construction should be such that inadvertent leakage or spills are prevented from reaching streams and sanitary or storm sewers.

2. Tank Cars and Tank Trucks

All bulk shipment equipment should be inspected for leaks immediately upon receipt. Drain pans must be provided to prevent spillage from unloading hoses and connections. Askarel liquid collected in drain pans should be placed in "SCRAP ASKAREL" drums for disposition.

3. Steel Drums, Cans, and Test Sample Containers

On delivery, all such shipments should be carefully inspected for leaks. The containers should be stored indoors in an area especially selected for this purpose. A curb should enclose the area to provide a basin for containing the askarel from one or more containers should the containers be damaged. The area must not have a drain which is connected to a sanitary or storm sewer.

If an indoor storage area is not possible, the containers should be stored under a lean-to.

E. Water Effluents - Sampling, Concentration Limits and Analytical Procedures

...Existing drain systems from manufacturing plants, repair shops and installation sites may be contaminated as a result of past practices.

1. Concentration Limits

The 1972 EPA proposals are to keep PCB levels in rivers and lakes below 0.01 parts per billion. Plant effluent streams should be managed and controlled in a manner consistent with this goal.

2. Monitoring Streams

All plant effluent streams should be monitored on a regular basis, consistent with plant situations. The procedures for performing the necessary analyses are contained in Section 5, "Analysis of Water and Sediment for Polychlorinated Biphenyls." This procedure or its equivalent shall be used.

3. Methods for Minimizing Effluent Stream Contamination

The ideal approach is to totally isolate all effluent streams that could be contaminated with askarels during manufacturing processes and prevent them from being discharged from the plant.

F. Disposal Procedures and Services

1. Sources of Materials Requiring Special Handling and Disposal Procedures

Liquids containing PCBs and solids containing or contaminated with PCBs may be obtained from any of the following sources: transport containers, transformer manufacturing processes, in-test failures, liquids contaminated beyond reclamation, in-service transformer leaks and failures, askarel-filled transformers scrapped for any reason, etc.

2. Classification for Disposal of Materials Containing PCBs

In general, there are three types of materials requiring disposal: liquids, burnable solid materials containing PCBs and nonburnable solid materials contaminated with PCBs.

a. Liquids. Liquids containing PCBs requiring disposal by high-temperature incineration may consist of the following:

(1) PCBs contaminated with mineral oil.

(2) Mineral oil contaminated with PCBs.

EXHIBIT III (2)
EPA
END-USES OF AROCLORS
(continued)

End-Use	1016	1221	1232	1242	1248	1254	1260	1262	1268
Miscellaneous Industrial									
. ashesives		X	X	X	X	X			
. wax extenders				X		X			X
. dedusting agents						X	X		
. inks						X			
. cutting oils						X			
. pesticide extenders						X			

Note: X denotes use of a given Aroclor in a specific end-use, while XX denotes principal use

Source: References 16, 36, 37, 38

MONS 043667

SECTION V

SECTION V

MANUFACTURING PROCESSES

The basic United States patents for the manufacture of chlorobiphenyls are

- U.S. 1,892,387 and 1,892,388 (December 27, 1932), R. L. Jenkins (to Swann Research, Inc.; reassigned to Monsanto Chemical Co.).
- U.S. 3,029,295 (April 10, 1962), Robert Thermet and Ludovic Parvi (to Societe d' Electro-Chimie D'Electro-metallurgie et des Acieries Electriques d' Ugine).
- U.S. 1,892,400 (December 27, 1932), R. L. Jenkins and J. A. Sikarski (to Swann Research, Inc.; reassigned to Monsanto Chemical Co.).

For a digest of selected process patents including recent developments see Exhibit IV.

1. THE MANUFACTURE OF PCBs IS NOT A COMPLEX PROCESS

PCBs can be prepared by chlorinating biphenyl with anhydrous chlorine in the presence of iron filings or ferric chloride as catalyst (11, 34).

- The product is a mixture of several PCBs and can be purified and fractionated by distillation
- The by-product is hydrogen chloride, which is neutralized before distillation
- The degree of chlorination is principally determined by the time of contact of biphenyl with anhydrous chlorine; 12 to 36 hours usually
- Reaction temperature is about 150°C. and pressure is near atmospheric

MONS 043669

- The degree of chlorination is measured by
  - the specific gravity of the mixture, or
  - the ball and ring softening point when the product is more viscous
- Overall, a batch or semi-continuous cascade process can be used.
- These processing fundamentals are featured both in U.S. and Western European installations.

(1) Currently There Is Only One Known Commercial Scale PCB Production Installation In The U.S.

- This facility is the William G. Krummrich plant of the Monsanto Industrial Chemicals Co. at Sauget, Illinois. The facility is specifically designed for chlorobiphenyls production
- The technology is not complex and other chemical firms and laboratories in the U.S. have the technical potential to produce PCBs
- Process flow in the Krummrich plant is summarized in Exhibit V.
  - reported yields are high, 97% or better (38)
  - there are 6 reactors, 3 batch and 3 cascade
  - batch size is about 2,500 gallons
  - a new distillation column was installed in 1971 at an estimated cost of almost one million dollars (37)
    - .. the gas fired unit enables production of Aroclors with minimized fractions of the highly chlorinated, persistent material

- .. the heel cut residues, representing about 2% of throughput, are drummed, diluted and incinerated

- transformer Aroclors can be diluted to 60-70% PCB with chlorobenzenes before shipping

- overall, the process has been simplified (except for environmental controls), since fewer Aroclors are manufactured including elimination of flaked product

(2) Monsanto Has Reported Significant Environmental Controls At The Krummrich Plant

. In Exhibit V a summary is provided of these controls

. The in-house goal has been reduction of PCBs in water discharges to less than one pound per day (38).

. The goal for air emissions is also less than one pound per day (36).

. An incinerator was erected at Sauget to process both Monsanto's own wastes and as a service to industry.

- the unit, costing $1,500,000, is sized to process about 10 million lbs. per year (14).

- controlled destruction takes place @ 2400°F. @ 2% excess O_2 over 1.5 sec. under an operating permit from the Illinois EPA (36).

- exhausts are passed through a high-energy venturi scrubber, then a packed column with weak muriatic acid; exhausts are monitored as well as discharges of neutralized scrubber liquor (36).

- the service charge is 3¢ per lb. (14, 36).

- there is a current backlog of roughly 250,000 lbs. of material to incinerate and about 20 million lbs. have been destroyed to date (36).

- the company no longer reprocesses contaminated materials

MONS 043671

2. HISTORICALLY, AROCLORS HAVE BEEN SHIPPED IN A FASHION SIMILAR TO ANY OTHER COMMODITY

The liquid chlorinated biphenyls have been packed and shipped in galvanized-steel drums or in tank cars constructed of nonrusting metals such as aluminum or tin-coated metal. The resinous products have been packed and shipped in open-top galvanized-steel drums, and the high-melting solid products are packed and shipped in bags. The railroad shipping classification is Resin Synthetic NOIBN.

Exhibit VI summarizes the historical shipping practices based on the description in Monsanto's technical bulletin on plasticizers (47).

It is reasonable to assume that the containers associated in the past with the distribution of Aroclors to Monsanto's open system customers have been a significant, but now declining, solid waste source of the environmental burden of PCBs.

Currently, Monsanto emphasizes the use of consigned tank cars for distribution to its 25-30 remaining customers, capacitor and transformer manufacturers (36). Shipping in 55 gallon steel drums still takes place for "topping" purposes. Exhibit VII is a sample of the type of label used for currently marketed Aroclors, providing explicit instructions for safeguards and uses.

The National Electrical Manufacturers Association (NEMA) has developed standard guidelines for shipping and handling of Aroclors. See Exhibits VIII and IX.

MONS 043672

3. THERE IS EVIDENCE OF RESEARCH AND DEVELOPMENT ACTIVITY TO CONTROL SPENT PCBs

The Monsanto incinerator is evidence of this, featuring a proprietary John Zink burner design (36).

Envirotech Corporation (23) reported that PCBs can be almost totally decomposed in multiple hearth incineration.

- A recent research project showed that PCB (Therminol FR-1) in waste sludges can be over 99.9% decomposed in a BSP multiple hearth furnace when operated at an exhaust gas temperature of 1100°F.
- The study shows that multiple hearth incineration can achieve more efficient PCB destruction in combination with sewage sludge than other types of incineration methods.
- A BSP furnace operating in the normal 1500-1700°F. range but with an exhaust gas temperature of only 1100°F. can decompose 99.9% of PCB in waste sludges 500°F. or more lower than previous norms.
- The majority of the heat required in a BSP furnace is normally supplied by the organic content of the waste sludges and the considerably lower exhaust temperature in the BSP furnace allows fuel savings of 60% in removing PCBs from the environment.

A Koochi University team in Japan has developed a caustic soda solution to completely decompose polychlorinated biphenyl (48).

- High pressure is said to turn the chlorine into sodium chloride within a short time.
- A pilot plant capable of decomposing 30 liters/hr. of PCB will be completed in 1973 at Koochi University and the group will continue experiments, also using alcohol and other solvents.

MONS 043673