# POLYCHLORINATED BIPHENYLS
# 1929 - 1979:
# FINAL REPORT

May 1979

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Toxic Substances
Washington, D. C. 20460

This document is available in limited quantities through the U. S. Environmental Protection Agency, Industry Assistance Office, Office of Toxic Substances (TS-793), 401 M Street, S.W., Washington, D.C. 20460.

This document will subsequently be available through the National Technical Information Service, Springfield, Virginia, 22151.

EPA 560/6-79-004

# POLYCHLORINATED BIPHENYLS 1929-1979:

## FINAL REPORT

Final Report

Submitted to:

U.S. Environmental Protection Agency
Office of Toxic Substances
Washington, D.C. 20460

Attention: Mr. Thomas E. Kopp
Project Officer

Contract No. 68-01-3259

Submitted by:

VERSAR, INC.
6621 Electronic Drive
Springfield, Virginia 22151
(703) 750-3000

May 16, 1979

This document is available in limited quantities through the U. S. Environmental Protection Agency, Industry Assistance Office, Office of Toxic Substances (TS-793), 401 M Street, S.W., Washington, D.C. 20460.

This document will subsequently be available through the National Technical Information Service, Springfield, Virginia, 22151.

## PREFACE

This report summarizes the work on Polychlorinated Biphenyls (PCBs) that Versar performed for the U.S. Environmental Protection Agency under Contract No. 68-01-3259. Mr. Thomas E. Kopp was the Program Manager for the EPA throughout the performance of this work, and his patient support is gratefully acknowledged.

PCBs were first manufactured in commercial quantities in the U.S. in 1930, and during the next 40 years they were widely used as solvents, resins, and electrical dielectric liquids. Recognition of their environmental persistence and toxicity in the late 1960's eventually led to a ban on the manufacture and use of PCBs in the Toxic Substances Control Act of 1976. This report summarizes the use of PCBs and much of the early literature on the uses and toxicity of this material. In addition, the report reviews the regulatory actions that have been taken to limit the hazards to health and the environment resulting from the accumulation of PCBs in the environment and from their continued use in certain electrical equipment. The report is primarily a summary of the reports that Versar has prepared in support of the EPA's regulatory activities involving PCBs.

TABLE OF CONTENTS

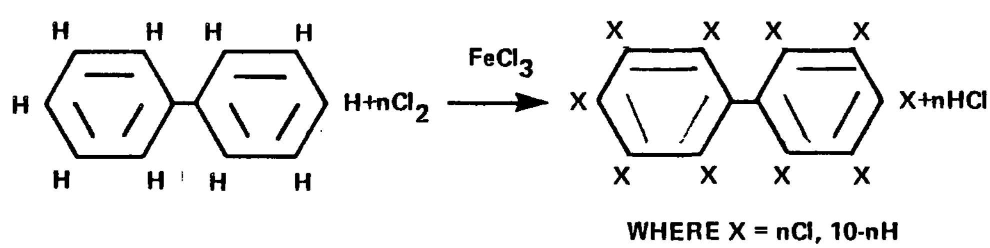
## 1.0 INTRODUCTION

On June 26, 1975, the U.S. Environmental Protection Agency awarded contract no. 68-01-3259 to Versar, Inc. Under this contract, it was anticipated that Versar would be assigned a number of tasks to assess the microeconomic impacts of regulatory alternatives which the EPA would consider for various toxic substances. The first task assigned under this contract required Versar to review and summarize the existing data on the use of polychlorinated biphenyls and to identify the industrial segments that might be impacted by regulations limiting the use of PCBs.

Before this task was completed, PCBs became a major issue within EPA, and the scope of the work assigned to Versar was increased as the agency required additional support. This report summarizes the work that Versar performed over the next four years for the EPA under the subject contract and a follow-on contract that was closely related to this work. All of this work supported regulatory activities involving PCBs, so the description of the work performed necessarily includes a history of the use of PCBs, a summary of regulatory development, and references to related research and reports.

## 2.0 POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls are a group of related compounds formed by the addition of chlorine to the aromatic hydrocarbon "biphenyl." The reaction can be described by the following equation:




### 2.1 History of PCB Usage:

PCBs were first synthesized and described in 1881 (Schmidt, 1881). Commercial production of PCBs did not become possible until after an economical method was developed during the 1920s for the manufacture of biphenyl from benzene.

Biphenyls were first produced in commercial quantities in the U. S. by Swann Research, Inc., of Anniston, Alabama. Shortly after they started manufacturing biphenyls, Swann Research described the manufacturing process (Jenkins, 1930) and the properties of the PCBs they were marketing under the tradename Aroclor (Penning, 1930). The various Aroclors were described as mixtures of chlorinated diphenyls with a wide range of properties from a light oil to a hard resin depending on the degree of chlorination. A number of commercial applications were suggested, including use in varnish, as a fireproofing agent for wood, in electrical equipment as a liquid dielectric and as a component of electrical insulation, as an ingredient in adhesives, as a replacement for Canada Balsam in microscopy, as a substitute for chicle in chewing gum, and in miscellaneous uses including printing inks and textile finishing (Penning 1930). A separate technical article described the compatibility of PCBs in nitrocellulose lacquer resins (Jenkins, 1931). The first major use of PCBs was apparently as a liquid dielectric in capacitors manufactured by General Electric Co. starting in 1930 (Clark, 1962). General Electric also developed the use of PCBs in other electrical applications as described in articles published during the 1930s (Clark, 1934; Clark, 1937).

PCBs were manufactured at the Anniston, Alabama, plant by Swann Research, Inc. and its corporate successor, Monsanto Chemicals Co., until the plant was shut down in 1971. Monsanto also manufactured PCBs at its plant at Sauget, Illinois, until 1977. The only other known U. S. manufacturer of PCBs was Geneva Industries of Houston, Texas, which manufactured PCBs for heat transfer applications from 1972 through 1974.

Most of the applications of PCBs that had been suggested in 1930 proved to be successful. PCBs were used as heat transfer liquids in critical applications such as food processing (Smith, 1955; Coulson, 1957), in various electrical applications (Clark, 1962), in sealants (Skrentny, 1971), in carbonless copy papers (Masuda, 1972; Lister, 1972), and in paint (Young, 1974). Polychlorinated terphenyls were suggested as a carrier for insecticides (Tsao, 1953; Sullivan, 1953). A Monsanto marketing guide to PCBs which was published in the late 1960s also described their possible use as expansion media in temperature sensing bellows devices, as liquid sealants for furnace roofs, as sealers for gaskets, as dedusting agents, in insecticides, in casting waxes, in abrasives, in lubricants and cutting oils, in adhesives, in polishing waxes and impregnating compounds, in coatings, in inks, in mastics, in sealing and caulking compounds, in tack coatings, and as plasticizers in plastics, paint, varnish, and lacquer. (Monsanto, undated). In addition, a number of other uses of PCBs had been patented over the years (for a list of patents see: Interdepartmental Task Force on PCBs, 1972, pp. 70-74).

The available data on the toxicity of PCBs was first summarized in an article published in 1931 (Smyth, 1931). Skin problems attributed to PCB exposure were later reported to be associated with various industrial processes including PCB manufacturing (Jones, 1936), capacitor manufacturing (Mayers, 1936), industrial painting (Birmingham, 1942), and electrical cable insulating (Good, 1943). Systemic effects of exposure to mixtures of chlorinated organic compounds including PCBs were also noted during the 1930s (Drinker, 1937) and were evaluated by animal exposure studies (Bennett, 1938; von Wedel, 1943; Miller, 1944.) In much of this early work, the toxicity studies used commercial mixtures which included chlorinated naphthalenes, and the effects of PCBs were not conclusively demonstrated (Drinker, 1939). Animal exposure tests eventually defined the toxicity of PCBs (Treon, 1946; McLaughlin, 1963; American Industrial Hygiene Assoc., 1965), and reports of worker health problems became limited to unusual situations (i.e., Meigs, 1954). Information on the toxicity of PCBs led the investigation of PCBs as a possible cause of chick edema disease (McCune, 1962; Flick, 1965) which was later demonstrated to be caused by contamination of feed with chlorinated dibenzodioxins.

During the early 1960s interest increased concerning the biological effects of environmental levels of chlorinated pesticide residues such as DDT and chlordane. Measurement of low levels of these compounds in biological samples required the development of sensitive analytical procedures that could both separate the pesticides from each other and from similar compounds and measure the amount of each compound present. The technique that was developed to perform this analysis was gas chromatography. In this method, a small amount of sample is introduced into a long heated tube which is packed with a material that has different adsorption characteristics for the different compounds in the sample. The tube is then flushed with an inert gas, and the different compounds are swept out of the tube at different times past a detector that is sensitive to the presence of chlorinated organic compounds and that gives a response proportional to the amount of chlorinated material in the stream of inert gas. The time required for each compound to move through the tube depends on the temperature, the type of packing, the rate of flushing with inert gas, and the characteristics of the particular compound. Therefore, the identification of the compounds in the environmental sample depends on knowing the retention time of the compounds and the response of the detector to each compound. This requires that known compounds be run through the column and detector, and as a result, only known compounds can be identified. Gas chromatography proved to be a very useful method for determining the concentrations of low levels of pesticides in environmental samples, but the detector usually recorded the presence of a number of chemicals that could not be identified by comparison with known pesticide chemicals.

In 1966, Soren Jensen attempted to identify the unknown compounds that were being recorded during routine pesticide analyses. In order to determine when the unknown compounds first appeared in biological samples, he analyzed feathers, from eagles that had been taken for museum collections. He found the unknown materials in feathers collected as early as 1944, before the widespread use of chlorinated pesticides, and so concluded that the unknown materials were not pesticides or degradation products of pesticides (Jensen, 1972). By testing chlorinated materials that were in wide use before 1944, he eventually identified commercial PCBs as the source of the unknown compounds, and published this finding in late 1966 (Jensen, 1966).

A full discussion of the presence of PCBs in pesticide analyses was published in 1967 (Widmark, 1967), and this set off a number of investigations to determine the extent of environmental contamination by PCBs. The discovery that PCBs were common in the environment in sufficient concentrations to affect the reproduction of wild birds was published in 1968 (Risebrough, 1968). This article was picked up in the press which started the widespread concern about possible human health effects from PCBs in the environment.

The Yusho incident that occurred in Japan during the summer of 1968 added to the public concern over the toxicity of PCBs. This was a case of widespread PCB poisoning caused by contamination of cooking oil. The PCBs were used a heat transfer liquid on the high temperature side of a heat exchanger used to pasturize the oil. Over 1000 people were seriously affected by eating contaminated oil (Kuratsune, 1971). The resulting concern over PCBs led to regulatory activity and increased research throughout the world. In July of 1971, a similar incident in the United States contaminated a considerable quantity of chicken feed as the result of leakage of PCB heat transfer fluid. The U.S. Food and Drug Administration eventually destroyed thousands of chickens and eggs that were fed this contaminated feed (Pichirallo, 1971). Starting in 1970, Monsanto voluntarily limited sales of PCBs to closed electrical equipment applications (Wood, 1975) and recommended that existing PCB-filled heat transfer systems be drained and refilled with non-PCB fluid (Monsanto, 1972). This voluntary ban was completed by the end of 1973. Monsanto closed the Anniston, Alabama, manufacturing plant at this time.

By 1972, a great deal of research had been completed on PCBs and was summarized in various review articles covering their toxicity (Kimbrough, 1972; Kimbrough, 1974), environmental impact (Peakall, 1972; Hammond, 1972), environmental distribution (Nisbet, 1972), uses (Broadhurst, 1972), presence in food (Fries, 1972) and chemical analysis (Reynolds, 1971). The basic information on PCBs was later compiled in the monograph "The Chemistry of PCBs" (Hutzinger, 1974). The amount of published information on PCBs has continued to grow rapidly since the early 1970s and is now most accessible through published literature surveys (Fuller, 1976; Kornreich, 1976) and annotated bibliographies (Quinby, 1972; Office of Water Resources Research, 1973; Office of Water Research and Technology, 1975; Cavagnaro, 1978).

## 2.2 PCB Use Restrictions and Government Regulations

The Yusho incident created considerable concern in the U. S. over possible contamination of food by PCBs. The U. S. Food and Drug Administration started routine sampling of foods for PCBs in 1969, and soon found that PCBs were present in fish from the Great Lakes, that there was PCB contamination of milk caused by use of PCBs as a solvent in pesticide sprays and as a component of sealants used in farm silos, and that there was contamination of chickens resulting from PCBs introduced into the feed as a component of ground bread cartons and wrappers. It has since become apparent that the presence of PCBs in fish is a problem that has existed since at least 1964 (Hartsough, 1965), although PCBs were not identified as the cause of the problem until 1971 (Aulerich, 1971; Aulerich, 1973).

From 1969 through 1971, the FDA established action levels for PCBs in food at 0.2 ppm in milk, 5 ppm in edible flesh of fish, 5 ppm in poultry, and 0.5 ppm in eggs. In 1970, the FDA prepared a summary of the available information on the chemistry and toxicity of PCBs (U. S. Department of Health, Education, and Welfare, 1970). In 1972, the FDA published a notice of proposed rulemaking (Federal Register, 37FR 5705). The U. S. Department of Agriculture also prepared a report on ways that it could act to limit PCB contamination of Food (U. S. Department of Agriculture Ad Hoc Group on PCBs, 1972.) In 1973, the FDA formally established limits for PCBs in food and animal feed (Federal Register, 38FR 18096). The FDA proposed a revision of these limits in 1977 (Federal Register, 42FR 17487), but no action has yet been taken on this proposal.

During 1970, the Council on Environmental Quality (CEQ) studied regulatory approaches to the problem of toxic chemicals in the environment. In its report "Toxic Substances" published in 1971, CEQ identified PCBs as a major problem (Council on Environmental Quality, 1971). The initial response of the responsible agencies was to establish a task force to review the available information on PCBs and recommend regulatory alternatives (Interdepartmental Task Force on PCBs, 1972).

During 1973 and 1974, the EPA proposed the establishment of water quality criteria for PCBs in industrial discharges as part of a program for establishing such criteria for a larger group of pesticides. However, PCBs were not covered in the effluent standards that were eventually promulgated.

The Occupational Safety and Health Administration adopted the standards for PCB exposure in industrial air that had previously been established by the American Industrial Hygiene Association. The National Institute of Occupational Safety and Health conducted a major review of available data and an extensive program of industry assessment in the mid 1970s, and the final report recommended that the allowable concentration of PCBs in the work place be reduced (NIOSH, 1977). However, OSHA has not yet taken action on this recommendation.

Government actions restricting the use of PCBs were not limited to the United States. Japan banned the manufacture and use of PCBs in the early 1970s because of public pressure following the Yusho incident. Sweden banned the use of PCBs at about the same time. International actions were also taken to reduce the risk of food contamination by PCBs during the early 1970s (OCED, 1973; OECD Council, 1973; The Council of the European Communities, 1976).

## 3.0 CONTRACT SUPPORT OF EPA ACTIONS ON PCBS

### 3.1 Support of Office of Toxic Substances

During 1974 and 1975, the Office of Toxic Substances sponsored a series of review studies to identify regulatory alternatives for various specified toxic substances. Contract 68-01-3259 was awarded by the EPA to Versar on June 26, 1975, to support similar work on additional chemicals. The first task on this new contract was assigned by the EPA Technical Project Officer, Mr. David Garrett, on June 27, 1975. This task required the contractor to study the role of PCBs in the U.S. economy and prepare a draft report by October 31, 1975, identifying and screening alternative regulatory and non-regulatory control options: Study of Regulatory Alternatives for PCBs: Draft Interim Report - Task I, October 31. (Unpublished - Superceded by "PCBs in the United States... .")

As part of the review of PCBs, the Office of Toxic Substances sponsored a national conference on PCBs in Chicago on November 19 thru 21, 1975.

The Technical Coordinator of this conference was Mr. Thomas Kopp of the Office of Toxic Substances. Several major articles on the environmental effects of PCBs that appeared in the popular press shortly before the conference (Boyle, 1975a; Boyle, 1975b) caused considerable public interest in the conference and a number of demands that EPA regulate PCBs. Dr. Robert Durfee of Versar participated in this conference and presented a paper summarizing the background on PCBs as presented in the draft report (Durfee, 1975).

Because of the increasing importance of PCBs to the activities of the Office of Toxic Substances after the conference, the EPA assigned Mr. Kopp as Technical Project Officer on the contract and had the contractor expand the draft interim report and prepare four special reports under Task I. The Versar Program Manager in charge of this work was Dr. Robert Durfee. The following reports were submitted in response to this directive:

The Handling and Disposal of Electric Transformers: Special Report, Task I (December 5, 1975). Non-proprietary sections included in "PCBs in the United States...."

Results from Review and Analysis of 308 Letter Responses on PCB Manufacturing, Usage, and Disposal in United States Industry: Special Report (December, 1975).

* Toxicological Studies Conducted Under Task I: Special Report (February 19, 1976). Incorporated in "PCBs in the United States..." as Appendix F.

* Development of an Economic Analysis Methodology for Evaluating Regulatory Alternatives for PCBs: Special Report, Task 1 (March 9, 1976). Unpublished.

* PCBs in the United States: Industrial Use and Environmental Distribution Final Report, Task I (February 25, 1976). EPA 560/6-76-005. NTIS PB 252 012.

At about the same time that Task I was expanded, the EPA directed the contractor to perform two additional tasks. Task II was a study of wastewater treatment technology that could be used to reduce the concentration of PCBs in industrial effluents. This work was supported by Clark, Dietz Associates who performed the industrial economic analysis under subcontract from Versar as provided by Modification 1 to the contract. Task III was a plan for an assessment of the use of PCBs

*See summary of report in Appendix C.

in the investment casting industry and the resulting environmental impacts. Versar program managers were Mr. Donald Sargent on Task II and Dr. Robert Durfee on Task III. The following reports were submitted in response to these work directives:

- * Assessment of Wastewater Management, Treatment Technology, and Associated Cost for Abatement of PCBs Concentration in Industrial Effluents: Final Report, Task II. (February 3, 1976). EPA 560/6-76-006. NTIS PB 251-433/AS.

- * Development of a Study Plan for Definition of PCBs Usage, Wastes, and Potential Substitution in the Investment Casting Industry: Final Report, Task III. (January, 1976) EPA 560/6-76-007. NTIS PB 251-842.

Based on these three tasks and on other work performed within the Environmental Protection Agency, the EPA published recommended disposal procedures for PCBs (Federal Register, 41 FR 14134) and proposed effluent standards for PCBs in the water discharges from PCB manufacturers and from capacitor and transformer manufacturers that used PCBs (Federal Register, 41 FR 30468).

Senator Gaylord Nelson introduced an amendment to the Toxic Substances Control Act (TSCA) on March 26, 1976. This amendment required the EPA to establish labeling and disposal requirements for PCBs and mandated an eventual ban on the manufacture and processing of PCBs. This amendment was incorporated into TSCA as Section 6(e) and became a legislated requirement when TSCA was signed into law on October 11, 1976. The effective date of TSCA was January 1, 1977.

On July 15, 1976, EPA modified the contract to support additional studies on several aspects of PCBs. EPA technical supervision of this work was the responsibility of Mr. Kopp. Under this contract modification (Mod. 4), four formal tasks were established and two additional reports were prepared for internal EPA use. The Versar program manager for this work was Mr. Robert Westin, with each report being the responsibility of a Versar Task Manager who was as the principal author of the report. The following reports were submitted in response to the requirements of this contract modification:

---

*See summary of report in Appendix C.

* PCBs Involvement in the Pulp and Paper Industry: Final Report, Task IV. EPA 560/6-77-005, NTIS PB 271-071/6WP. February 25, 1977.

* A First Order Mass Balance Model for the Sources, Distribution, and Fate of PCBs in the Environment: Final Report, Task V. EPA 560/6-77-006, NTIS PB 270-220. July, 1977.

* Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs: Final Report, Task VI. EPA 560/6-77-007, NTIS PB 270-225. July 1977.

* Assessment of the Use of Selected Replacement Fluids for PCBs in Electrical Equipment: Final Report, Task VII. EPA 560/6-77-008, NTIS No. forthcoming. April, 1979.

Environmental Discharges of PCBs Associated with the Manufacture and Use of PCBs and PCB-Containing Equipment. (Contains EPA proprietary Information, submitted to EPA Enforcement Division.) October 29, 1976.

Usage of PCBs in Open and Semi-Closed Systems and the Resulting Losses of PCBs to the Environment. (Contains EPA proprietary information, submitted to EPA Enforcement Division). September 30, 1976.

### 3.2 Support of the Criteria and Standards Division

Versar provided support to the Criteria and Standards Division of EPA under three separate contract modifications. All of the work involved support of the effluent standards for PCBs by performing additional technical and economic analysis of the feasibility and costs of various pollution abatement technologies. The EPA Technical Program Manager on this work was Mr. Thomas Kopp, and the EPA Task Manager was Mr. Ralph Holtje of the Criteria and Standards Division. The Versar Program Manager was Mr. Donald Sargent. The contract modification requirements and the reports submitted were as follows:

Modification 2 (Feb. 27, 1976): Provided for the analysis of the economic impacts of the proposed regulation by Jack Faucett Associates under subcontract from Versar and for the review of the Final Task II report by Versar.

*See summary of report in Appendix C.

* PCBs Water Elimination/Reduction Technology and Associated Costs: Manufacturers of Electrical Capacitors and Transformers: Addendum to Final Report, Task II. EPA 440/9-76-020. July 2, 1976.

Recommendations as to PCB Sampling Sites and Sampling Points at Industrial Sources: Special Report. August 17, 1976.

* Economic Analysis of Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls: Transformer, Capacitor, and PCB Manufacturing. (Prepared by Jack Faucett Associates) EPA 230/1-76-068. October, 1976.

Modification 3 (June 10, 1976): Provided for additional assessment of wastewater management and treatment technology and support of EPA during formal hearings and rulemaking proceedings.

* Costs for U.V. - Ozonation Process: Addendum to Final Report, Task II. September 27, 1976. Unpublished.

* Detailed Cost Estimates for Alternative PCBs Treatment Technologies Applied to Hypothetical Large and Medium Sized PCB Capacitor and Transformer Manufacturing Plants. Addendum to Final Report, Task II. October 15, 1976. Unpublished.

* Cost for Equalization Basin Based on Bentonite Clay Liner Special Report, October, 1976. Unpublished.

* Impacts of Substitutes for PCBs on Fire Hazards in Commercial and Residential Buildings: (Draft) Special Report. October, 1976. Unpublished.

* Recent Advances in PCBs Detoxification in Wastewater: Supplement to Final Report, Task II. January 18, 1977. Unpublished.

* PCB Levels in Non-Contact Cooling Waters and Other Effluents from Capacitor and Transformer Production Facilities: Supplement to Final Report, Task II. January 18, 1977. Unpublished.

* Refinement of Alternative Technologies and Estimated Costs for Reduction of PCBs in Industrial Wastewaters from the Capacitor and Transformer Manufacturing Categories. January 19, 1977. Unpublished.

* Costs Associated with Installing Production Equipment for Use of Non-PCB Dielectric Fluids in Transformer and Capacitor Manufacture: Supplement to Final Report, Task II. January 19, 1977. Unpublished.

*See summary of report in Appendix C.

On February 2, 1977, the EPA promulgated effluent standards restricting any discharges of PCBs in the wastewaters from manufacturers of PCBs or from capacitor and transformer manufacturing plants that used PCBs after February 2, 1978 (Federal Register, 42 FR6531).

3.3 Support of PCB Work Group - Disposal and Marking Regulations

Section 6(e)(1) of the Toxic Substances Control Act required the EPA to regulate the labeling and disposal of PCBs by July 1, 1977. On December 8, 1976, the EPA announced the formation of a PCB Work Group to write the proposed rules. The contractor provided staff support to this work group, providing a number of special reports as requested, performing the economic impact analysis of the proposed regulation, and providing testimony at the rulemaking hearing. The contract was modified on March 25, 1977, (Mod. 6) to authorize this additional technical and economic support. The EPA Project Officer for this work was Mr. David Wagner, and Mr. Thomas Kopp remained the Technical Project Officer in charge of the total contract. The Versar Program Manager was Mr. Robert Westin. The following reports were submitted in support of the development of the PCB Marking and Disposal Regulations:

Assessment Methodology for Labeling and Education to Assure the Proper Disposal of PCBs: Special Report. November, 1976.

Analysis of the Economic and Technological Constraints on the Disposal of PCBs: Special Report. November 22, 1976.

PCB Disposal Regulations: Problem Areas and Regulatory Alternatives: Special Report. December 10, 1976.

Estimated Usage of Electrical Equipment Containing PCBs: Special Report. December 23, 1976.

Recommended Label Requirements and Suggested Label Formats: Special Report. January 12, 1977.

Draft Notice of Public Meeting - PCBs. January 10, 1977.

Comments on PCB Definitions to Subcommittee on Manufacturing Bans. January 14, 1977.

*See summary in Appendix C.

Draft Notice of Proposed Rulemaking, Preamble, and Labeling and Disposal Regulations: Special Report. January 21, 1977; revised February 4, 1977.

Labeling and Disposal Regulations: Revised Draft. January 27, 1977.

Draft Preamble to PCB Disposal Regulation. December 29, 1976: revised January 12, 1977; revised February 4, 1977.

Economic Impact - Summary and Conclusions: Special Report. March 14, 1977.

Statement of Economic Consequences of the Rule: Special Report. April 12, 1977.

* Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs. April, 1977. EPA 560/6-77-013, NTIS PB 267-833.

EPA formally proposed the rules for marking and disposal of PCBs on May 24, 1977 (Federal Register, 42 FR 26564). Rulemaking hearings were held on June 24, 27, 28, and 29. Mr. Westin of Versar presented testimony on the economic impacts of the proposed regulation at the hearings on June 29. The EPA promulgated the PCB Disposal and Marking Regulations on February 17, 1978 (Federal Register, 43 FR 7150) and issued corrections on August 2, 1978 (Federal Register, 43 FR 33918). The effective date of the regulations was April 18, 1978.

### 3.4 Support of PCB Work Group - PCB Ban Regulations

Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act banned the manufacturing, processing, distribution, and use of PCBs after January 1, 1978, except in a totally enclosed manner; completely banned the manufacture of PCBs after January 1, 1979; and completely banned the processing and distribution in commerce of PCBs after July 1, 1979. However, the Act also authorized the EPA to exempt those activities involving PCBs that did not present an unreasonable risk of injury to health or the environment provided

*See summary in Appendix C.

that good faith efforts were made to develop an adequate substitute for PCBs in that use. On June 27, 1977, the EPA announced the formation of a PCB work group to develop proposed regulations implementing these provisions of the act, and announced public meetings on the subject to be held in Washington, D.C. on July 19, 1977 (Federal Register, 42 FR 32555).

EPA modified the contract on June 26, 1977, (Mod. 7) to provide for support during the development of the proposed ban regulations. EPA Project Officers continued to be Mr. Wagner and Mr. Kopp. Versar's work was supervised by Mr. Westin. Versar prepared briefing papers for the work group prior to the public meetings and submitted them to the work group as the special report: Potential Impacts of the Bans on PCB Manufacturing, Processing, and Use: PCB Activity Analysis Papers (July 11, 1977).* Following the public meetings, the work group prepared a draft of the proposed regulations (August 30, 1977), and the contractor submitted a formal report on the economic impacts of these regulations: Microeconomic Impacts of the Draft "PCB Ban Regulations": Draft Report (September 18, 1977). Formal proposal of the ban regulations was delayed while the Work Group prepared the final version of the Disposal and Marking Regulations, and on December 30, 1977, EPA announced that it would not enforce the January 1, 1978 ban on open system activities involving PCBs until after formal ban regulations were promulgated (Federal Register, 42 FR 65264).

The work group continued to revise the draft proposed regulation, and Versar submitted a major revision of the economic impact analysis reflecting the changes in the proposed regulation and including appendices characterizing the U.S. waste oil industry and presenting a formal microeconomic analysis of the supply and demand effects of the PCB Ban on the electric equipment industry: Microeconomic Impacts of the Draft "PCB Ban Regulations": Revised Draft Report (March 8, 1978).*

### 3.5 Support of EPA Office of Planning and Management - PCB Ban Regulations

In early 1978, the EPA transferred responsibility for the analysis of the economic impacts of the PCB ban regulations from the PCB Work Group to the

*See summary in Appendix C.

Office of Planning and Management. On April 19, 1978, the EPA awarded contract number 68-01-4771 to Versar for additional economic analysis, preparation of a revision of the previously submitted draft economic impact report, and support during the public hearings on the proposed regulations. The EPA Technical Project Officer was Mr. Steven B. Malkensen, Office of Planning and Management. The Versar Program Manager was Mr. Robert Westin. In May, 1978, the contractor submitted the revised report: Microeconomic Impacts of the Proposed "PCB Ban Regulations"* that was issued in support of the proposed regulations as EPA Report No. EPA-560/6-77-035.

The EPA formally proposed the PCB Ban Regulations on June 7, 1978 (Federal Register, 43 FR 24801). Public Hearings were held in Washington, D. C., from August 21 through September 1, 1978. Mr. Westin of Versar presented testimony on the economic impacts of the proposed regulations on September 26, 1978.

Following the hearings, EPA continued to revise the ban regulations. On November 1, 1978, EPA published interim procedural rules for filing and processing petitions for exemptions from the January 1, 1979 bans on manufacturing of PCBs (Federal Register, 43 FR 50905). On January 2, 1979, EPA announced that it would not enforce the prohibitions on PCB manufacturing, processing, distribution in commerce, and use until after formal promulgation of the PCB Ban Regulations (Federal Register, 44 FR 108).

On November 15, 1978, Versar submitted a draft report on the economic impacts of the draft ban regulations: PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis: Draft Final Report. A major revision of this report was submitted on December 22, 1978. On December 27, 1978, EPA modified contract 68-01-4771 to extend the duration of the contract and to fund further revisions of the economic impact analyses as required by additional changes to the draft regulation. Mr. Stephen Weil was assigned to be the EPA Technical Project Officer for this contract modification. The contractor submitted the final revision of this

*See summary in Appendix C.

report on March 30, 1979.* EPA issued the final regulations on April 19, 1979. Formal promulgation of the regulations through the Federal Register was expected to occur by the end of May, 1979.

*See summary in Appendix C.

## References

American Industrial Hygiene Association (1965). "Chlorodiphenyls (containing 42% and 54% chlorine)." Hygienic Guide Series, Jan-Feb.

Aulerich, R.J.; Ringer, R.K.; Seagron, H.L.; Youatt, W.G. (1971). "Effects of Feeding Coho Salmon and Other Great Lakes Fish on Mink Reproduction." Canadian Journal of Zoology, Vol. 49, p. 611.

Aulerich, R.J.; Ringer, R.K.; Iwamoto, S. (1973). "Reproductive Failure and Mortality in Mink Fed on Great Lakes Fish." Journal of Reproduction and Fertility. Vol. 19 (Suppl), pp. 365-376.

Bennett, G.A.; Drinker, C.K.; Warren, M.F. (1938). "Morphological Changes in the Livers of Rats Resulting from Exposure to Certain Chlorinated Hydrocarbons." The Journal of Industrial Hygiene and Toxicology. Vol. 20, No. 2 (February), pp. 97-123, (Feb. 1938).

Birmingham, D.J. (1942). "Occupational Dermatology: Current Problems." Skin, Vol. 3, pp. 38-42.

Boyle, R.H. (1975a). "Of PCB ppms from GE and a SNAFU from EPA and DEC," Audubon, Vol. 77, No. 6 (Nov. 1975), pp. 127-133.

Boyle, R.H. (1975b). "Poisoned Fish, Troubled Waters." Sports Illustrated, Sept. 1, 1975, pp. 14-17.

Broadhurst, M.G. (1972). "Use and Replaceability of Polychlorinated Biphenyls," Environmental Health Perspectives, Vol. 2, pp. 81-102.

Cavagnaro, D.M. (1978). Polychlorinated Biphenyls in the Environment (A Bibliography with Abstracts). Springfield, Va: National Technical Information Service (NTIS/PS-78/0893/4WP) August, 1978.

Clark, F.M. (1934). "The Development and Application of Synthetic Liquid Dielectrics." Transactions of the Electrochemical Society, Vol. 45, p. 59.

Clark, F.M. (1937). "Nonflammable Dielectric Organic Compounds." Industrial and Engineering Chemistry, Vol. 29, p. 698.

Clark, Frank M. (1962). Insulating Materials for Design and Engineering Practice, New York: John Wiley and Sons, Inc.

Coalson, H.; Sellers, K.W. (1957). "Modern Potato Chip Production." Taylor Technology, Spring, 1957, pp. 14-18.

Council on Environmental Quality (1971). Toxic Substances, Washington, D. C.

References (Continued)


Drinker, C.K. (1939). "Further Observations on the Possible Systemic Toxicity of Certain of the Chlorinated Hydrocarbons with Suggestions for Permissible Concentrations in the Air of Workrooms." The Journal of Industrial Hygiene and Toxicology, Vol. 21, No. 5 (May), pp. 155-159.

Drinker, C.K.; Warren, M.F.; Bennett, G.A. (1937). "The Problem of Possible Systemic Effects from Certain Chlorinated Hydrocarbons." The Journal of Industrial Hygiene and Toxicology, Vol. 19, No. 7 (September), pp. 283-311.

Durfee, R.L. (Versar Inc.). (1975). "Production and Usage of PCBs in the United States." Conference Proceedings: National Conference on Polychlorinated Biphenyls (Report No. EPA-560/6-75-004). Washington, D. C.: Office of Toxic Substances, U.S. Environmental Protection Agency. March, 1976, pp. 103-107.

Flick, D.F.; O'Dell, R.G.; Childs, V.A. (1965). "Studies of the Chick Edema Disease. 3. Similarity of Symptoms Produced by Feeding Chlorinated Biphenyls." Poultry Science, Vol. 44, No. 6, p. 1460-1465.

Fries, G.F. (1972). "PCB Residues: Their Significance to Animal Agriculture." Agricultural Science Review, 3rd Quarter, pp. 19-24.

Fuller, B.; Gordon, J.; Kornreich, M. (MITRE Corp.). (1976). Environmental Assessment of PCBs in the Atmosphere. Springfield, Va.: National Technical Information Service (NTIS PB-274 115/5WP).

Good, C.K.; Pensky, N. (1943). "Halowax Acne (Cable Rash)." Archives of Dermatology and Syphilogy, Vol. 48, p. 251.

Hammond, P.B.; Nisbet, C.T.; Sarofim, A.F.; Drury, W.H.; Nelson, N. (1972). "Polychlorinated Biphenyls - Environmental Impact, A Review by the Panel on Hazardous Trace Substances." Environmental Research, Vol. 5, pp. 247-362 (Sept. 1972).

Hartsough, G.R. (1965). "Great Lakes Fish Now Suspect as Mink Food." American Fur Breeder, Vol. 38, p. 25.

Hutzinger, O.; Safe, S.; Zitko, V. (1974). The Chemistry of PCBs, Cleveland, Ohio: CRC Press.

Interdepartmental Task Force on PCBs. (1972). Polychlorinated Biphenyls and the Environment. Springfield, Va.: National Technical Information Service (Report No. NTIS COM-72-10419).

Jenkins, R.L.; McCollough, R.; Booth, C.F. (1930). "Syntheses in the Diphenyl Series." Industrial and Engineering Chemistry, Vol. 22, p. 31.

Jenkins, R.L.; Foster, R.N. (1931). "Compatibility Relationships of Aroclors in Nitrocellulose Lacquers." Industrial and Engineering Chemistry, Vol. 23, No. 12 (Dec. 1931), pp. 1362-1365.

References (Continued)

Jensen, Soren. (1966). "Report of a New Chemical Hazard." New Scientist, Vol. 32, p. 612.

Jensen, Soren. (1972). "The PCB Story." Ambio, Vol. 1, No. 4, (August, 1972) pp. 123-131.

Jones, J.W.; Alden, H.W. (1936). "An Acneiform Dermatergosis." Archives of Dermatology and Syphilogy, Vol. 33, pp. 1022-1034.

Kimbrough, R.D. (1972). "Toxicity of Chlorinated Hydrocarbons and Related Compounds." Archives Environmental Health, Vol. 25, pp. 125-131.

Kimbrough, R.D. (1974). "The Toxicity of Polychlorinated Polycyclic Compounds and Related Chemicals." CRC Critical Reviews in Toxicology, January, 1974, pp. 445-498.

Kornreich, M.; Fuller, B.; Dorigan, J.; Walker, P.; Thomas, L. (Mitre Corp.) (1976). Environmental Impact of Polychlorinated Biphenyls. Draft Report. ERDA Contract No. E(40-1) - 4993. McLean, Va: The Mitre Corporation (Report No. MTR-7006).

Kuratsune, M.; Yoshimura, T.; Matsuzaka, J.; Yamaguchi, A. (1971). "Yusho, a Poisoning Caused by Rice Oil Contaminated with Polychlorinated Biphenyls." HSMHA Health Reports, Vol. 86, No. 12, pp. 1083-1091.

Lister, R.E.; Bennett, N.J.M. (1972). "PCBs in Copying Paper," Nature (London), Vol. 237, p. 414.

Masuda, Y.; Kagawa, R. (1972). "Polychlorinated Biphenyls in Carbonless Copying Paper." Nature (London), Vol. 237 (5/5), pp. 41-42.

Mayers, M.R.; Silverberg, M.G. (1938). "Skin Conditions Resulting from Exposure to Certain Chlorinated Hydrocarbons." The Journal of Industrial Hygiene and Toxicology, Vol. 20 p. 244.

McCune, E.L; Savage, J.E.; O'Dell, B.L. (1962). "Hydropericardium and Ascites in Chicks Fed a Chlorinated Hydrocarbon." Poultry Science, Vol. 41, p. 295.

McLaughlin, J.; Marliae, G.P.; Verrett, M.J.; Mutchler, M.K.; Fritzlaugh, O.G. (1963). "The Injection of Chemicals Into the Yolk Sac of Fertile Eggs Prior to Incubation as Toxicity Test." Toxicol. Appl. Pharmacol., Vol. 5, pp. 760-771.

Meigs, W.J.; Alborn, J.J.; Kartin, B.L. (1954). "Chloracne from an Unusual Exposure to Aroclor." Journal of the American Medical Association, Vol. 154, pp. 1417-1418.

Miller, J.W. (1944). "Pathologic Changes in Animals Exposed to Commercial Chlorinated Diphenyl." Public Health Reports, Vol. 59, pp. 1085-1093, (August 18, 1944).

References (Continued)

Monsanto Chemical Co. (undated). The Aroclor Compounds, St. Louis, Mo:

Monsanto Industrial Chemicals Co. (1972). Therminol Conversion Bulletin SP/TC-1. St. Louis, Mo.: January, 1972.

NIOSH. (1977). Criteria for a Recommended Standard. Occupational Exposure to Polychlorinated Biphenyls (PCBs). DHEW (NIOSH) Publication No. 77-225. Washington, D.C.: U.S. Government Printing Office.

Nisbet, C.T.; Sarofim, A.F. (1972). "Rates and Routes of Transport of PCBs in the Environment." Environmental Health Perspectives. Exp. 1, pp. 21-38.

OECD. (1973). Polychlorinated Biphenyls: Their Use and Control. Paris, France: Environmental Directorate from the Organization for Economic Cooperation and Development.

OECD Council (1973). "Protection of the Environment by Control of Polychlorinated Biphenyls: Decision Adopted 13 February, 1973." as cited in: OECD and the Environment. Paris: Organization for Economic Co-operation and Development, 1976, pp. 17-24.

Office of Water Resources Research, U.S. Department of the Interior (1973). PCB in Water - A Bibliography. Springfield, Va.: National Technical Information Service (NTIS-PB-217-859).

Office of Water Research and Technology, U.S. Department of the Interior, (1975). PCB in Water: A Bibliography, Vol. 2. Springfield, Va.: National Technical Information Service (NTIS-PB-248-141).

Peakall, D.B. (1972). "Polychlorinated Biphenyls: Occurrence and Biological Effects." Residue Review, Vol. 44, pp. 1-21.

Penning, C.H. (1930). "Physical Characteristics and Commercial Possibilities of Chlorinated Biphenyl. Industrial and Engineering Chemistry, Vol. 22, p. 1180.

Pichirallo, J. (1971). "PCBs: Leaks of Toxic Substances Raise Issue of Effects, Regulation." Science, Vol. 173, p. 899. (Sept. 3, 1971).

Quinby, G.E. (1972). Polychlorobiphenyls (PCBs) and Related Chlorophenyls: Effects on Health and Environment - I: Bibliography -- 1881-1971. Springfield, Va.: National Technical Information Service (NTIS PB-209-944).

Reynolds, L.M. (1971). "Pesticide Residue Analysis in the Presence of Polychlorobiphenyls (PCBs)." Residue Reviews, Vol. 34, pp. 27-57.

Risebrough, Robert W.; Reiche, P.; Peakall, D.B.; Herman, S.C.; Kirven, M.N. (1968). "Polychlorinated Biphenyls in the Global Ecosystem." Nature, (London), Vol. 220, (Dec. 1968), pp. 1098-1102.

References (Continued)

Schmidt, H., and Schultz, G. (1881). "Uber Diphenylbasen." Annalen Chem., Vol. 207, pp. 338-344.

Skrentny, R.F.; Hemken, R.W.; Dorough, H.W.; (1971). "Silo Sealants as a Source of Polychlorobiphenyl (PCB) Contamination of Animal Feed." Bulletin of Environmental Contamination and Toxicology, Vol. 6, No. 5, pp. 409-416.

Smith, H.L.; Freeman, W.E. (1955). "Automatic Remote Heating Cures Frying Faults." Food Engineering, March, 1955, pp. 60-62, 205.

Smyth, H.F. (1931). "Toxicity of Certain Benzene Derivatives and Related Compounds." The Journal of Industrial Hygiene and Toxicology, Vol. 13, pp. 87-96.

Sullivan, W.N.; Hornstein, I. (1953). "Chlorinated Polyphenyls to Improve Lindane Residues." Journal of Economic Entomology, Vol. 46, No. 1, pp. 158-159. (February, 1953).

The Council of the European Communities (1976). "Council Directive of 27 July, 1976." Official Journal of the European Communities, No. L 262, p. 201-203 (Sept. 27, 1976).

Treon, J. F.; Cleveland, F.P.; Cappel, J.W.; Atchley, R.W. (1956). "The Toxicity of the Vapors of Aroclor 1242 and Aroclor 1254." American Industrial Hygiene Association Quarterly, Vol. 17, No. 3, pp. 204-213.

Tsao, Ching Hsi; Sullivan, W.N.; Hornstein, I. (1953). "A Comparison of Evaporation Rates and Toxicity to House Flies of Lindane and Lindane-Chlorinated Polyphenyl Deposits." Journal of Economic Entomology, Vol. 46, No. 5, pp. 882-884 (October, 1953).

U.S. Department of Agriculture Ad Hoc Group on PCBs (1972). Agriculture's Responsibility Concerning Polychlorinated Biphenyls (PCBs). Washington, D.C.: Office of Science and Education, U.S. Department of Agriculture.

U.S. Department of Health, Education, and Welfare (1970). Supplement 1 - Status Report on the Chemistry and Toxicology of Polychlorinated Biphenyls (PCB) of Aroclors. Washington, D.C.: Bureau of Foods, Food and Drug Administration, Public Health Service.

Von Wedel, H.; Holla, W.A.; Denton, J. (1943). "Observations on the Toxic Effects Resulting from Exposure to Chlorinated Naphthalene and Chlorinated Phenyls with Suggestions for Prevention." The Rubber Age, Vol. 53, No. 5, pp. 419-426 (August, 1943).

Widmark, G. (1967). "Possible Interference by Chlorinated Biphenyls." J. Assoc. Off. Anal. Chem., Vol. 50, p. 1069.

References (Continued)

Wood, David (Monsanto Industrial Chemicals Co.) (1975). "Chlorinated Biphenyl Dielectrics - Their Untility and Potential Substitutes." Conference Proceedings: National Conference on Polychlorinated Biphenyls (Report No. EPA-560/675-004). Washington, D.C.: Office of Toxic Substances, U.S. Environmental Protection Agency, March, 1976, pp. 317-324.

Young, D.R.; Heesen, T.C.; McDermott, D.J.; Smoklev, P.E. (1974). "Marine Inputs of Polychlorinated Biphenyls and Copper from Vessel Antifouling Paints." Southern California Coastal Water Research Project, TM 212, (May, 1974).

# APPENDIX A

## FEDERAL REGISTER NOTICES REGARDING PCBs

## Environmental Protection Agency

### Effluent Limitations (§ 307a Clean Water Act)

| Date | Vol. | Pages | Subject |
|---|---|---|---|
| July 6, 1973 | 38 | 18044-5 | Proposed List of Toxic Pollutants, Including PCBs. |
| Sept 7, 1973 | 38 | 24342-4 | Promulgated List of Toxic Pollutants, Including PCBs. |
| Dec 27, 1973 | 38 | 35388-95 | Proposed Water Effluent Standards, Including PCBs. |
| Mar 5, 1974 | 39 | 8325-6 | Public Hearings on Effluent Standards. |
| Mar 21, 1974 | 39 | 10603-4 | Correction - Effluent Standards. |
| Jul 23, 1976 | 41 | 30468-77 | Proposed Effluent Standards. |
| Feb 2, 1977 | 42 | 6531-55 | Effluent Standard Regulations. |

### Spill Reporting Requirements (§ 311, Clean Water Act)

| Date | Vol. | Pages | Subject |
|---|---|---|---|
| Feb 16, 1979 | 44 | 10266 | Definition of "Discharge" under Clean Water Act. |
| Feb 16, 1979 | 44 | 10271-84 | Defines Reportable Quantities of PCBs Spilled into Waterways, Reporting Requirements and Fines. |

Disposal and Marking Regulations (§ 6el) Toxic Substances Control Act

| Date | Vol. | Pages | Subject |
|---|---|---|---|
| Apr 1, 1976 | 41 | 14134-36 | Recommended Disposal Procedures. |
| Dec 8, 1976 | 41 | 53692 | Panel Discussion/Formation of PCB Work Group. |
| Jan 5, 1977 | 42 | 1067 | Rescheduling of Meeting. |
| Jan 19, 1977 | 42 | 3701-2 | Notice of Jan. 24, 1977 Public Meeting. |
| Apr 21, 1977 | 42 | 20640-44 | Proposed Procedures for Rule-Making under Sect. 6 of TSCA. |
| May 24, 1977 | 42 | 26564-77 | Proposed Marking and Disposal Regulations. |
| Jul 15, 1977 | 42 | 36484-85 | Deadline for Reply Comment Period. |
| Feb 17, 1978 | 43 | 7150-64 | Promulgated Marking and Disposal Regulations. |
| Jul 18, 1978 | 43 | 30882-3 | List of Approved PCB Disposal Facilities. |
| Aug 2, 1978 | 43 | 33918-20 | Corrections to Marking & Disposal Regulations. |
| Aug 25, 1978 | 43 | 38087-88 | List of Approved PCB Disposal Facilities. |
| Oct 26, 1978 | 43 | 50041 | List of Approved PCB Disposal Facilities. |
| Dec 20, 1978 | 43 | 59432-3 | List of Approved PCB Disposal Facilities. |
| Mar 12, 1979 | 44 | 13575 | Request for Comments on Citizens' Petition to Give Regional Administrators Authority to Approve Alternate Disposal Methods. |

Ban Regulations (§ 6e2, 6e3, etc.) Toxic Substances Control Act

| Date | Vol. | Pages | Subject |
|---|---|---|---|
| Jun 27, 1977 | 42 | 32555 | Notice of July 19 Chicago Hearing. |
| Dec 30, 1977 | 42 | 65264 | Notice that EPA Would Not Enforce Ban on Uses in "Other Than a Totally Enclosed Manner." |
| Jun 7, 1978 | 43 | 24802-17 | Proposed Ban Regulations. |
| Jun 7, 1978 | 43 | 24818 | Requires Notification of Intent to Export. |
| Aug 25, 1978 | 43 | 38057 | Incorporates Hearing Record of Effluent Standard Regulations into Hearing Record for Ban Regulations. |
| Sept 22, 1978 | 43 | 43048 | Notice of Cross-Examination of Versar. |
| Nov 1, 1978 | 43 | 50905-07 | Interim Rules: Applications for Exemption from PCB manufacturing ban. |
| Jan 2, 1979 | 44 | 108-109 | Notice that enforcement is postponed until regulations are promulgated. |
| May 31, 1979 | 44 | | Promulgated Ban Regulations |

## Food and Drug Administration

| Date | Vol. | Pages | Subject |
|---|---|---|---|
| 1972 | 37 | 5705-5707 | Notice of Proposed Rule-Making. |
| Jul 6, 1973 | 38 | 18096-103 | Limits of PCBs in Foods, etc., Aug. 8 Corrections. |
| 1975 | 40 | 11563-66 | PCBs in Paper/Food Packaging Material. |
| Apr 1, 1977 | 42 | 17487-94 | PCBs in Food - Proposed Changes. |

## National Cancer Institute

| Date | Vol. | Pages | Subject |
|---|---|---|---|
| Apr 21, 1978 | 43 | 17060 | Carcinogenicity of Aroclor 1254. |

# APPENDIX B

## VERSAR REPORTS TO EPA RELATED TO PCBs

Contract 68-01-3259 - EPA: Mr. Thomas Kopp, EPA Technical Project Officer

Office of Toxic Substances

Durfee, R. L.; Contos, G. Y.; and Whitmore, F. C. "Study of Regulatory Alternatives for PCBs," Draft Interim Report, Task I. October 31, 1975. Unpublished. (Superseded by PCBs in the United States...")

Westin, R. A. "The Handling and Disposal of Electric Transformers," Special Report, Task I, EPA Proprietary Data. December 5, 1975. Unpublished. (Non-proprietary parts included in "PCBs in the United States...")

*Pallotta, A. J. "Toxicological Studies Conducted Under Task I: Special Report." Washington, D. C.: Office of Toxic Substances, U. S. Environmental Protection Agency, February 19, 1976. (Included in "PCBs in the United States..." as Appendix F).

*Durfee, R. L.; Contos, G. Y.; Whitmore, F. C.; Barden, J. D.; Hackman, E. E.; and Westin, R. A. "PCBs in the United States: Industrial Use and Environmental Distribution," Final Report, Task I (EPA 560/6-76-005). Springfield, Va.: National Technical Information Service (NTIS PB 252-012), February 25, 1976.

*Mosbaek, E. (Jack Faucett Associates), "Development of an Economic Analysis Methodology for Evaluating Regulatory Alternatives for PCBs," Special Report, Task I. March 9, 1976. Unpublished.

Contos, G. Y. and Durfee, R. L. "Results from Review and Analysis of 308 Letter Responses on PCB Manufacturing, Usage, and Disposal in United States Industry." (EPA Proprietary Information, submitted to EPA Enforcement Division) November, 1975. Unpublished.

*Contos, G.; Durfee, R. L.; Hackman, E. E. (Versar, Inc.), and Price, K. (Clark, Dietz and Associates). "Assessment of Wastewater Management, Treatment Technology, and Associated Cost for Abatement of PCBs Concentration in Industrial Effluents," Final Report, Task II (EPA 560/6-76-006). Springfield, Virginia: National Technical Information Service (NTIS PB 251-433/AS), February 3, 1976.

*Barden, J. D. Durfee, R. L. "Development of a Study Plan for Definition of PCBs Usage, Wastes, and Potential Substitution in the Investment Casting Industry," Final Report, Task III (EPA 560/6-76-007). January, 1976. Springfield, Va.: National Technical Information Service (NTIS PB 251-842).

*Carr, R. A.; Contos, G. Y.; Durfee, R. L.; Fong, C. C.; and McKay, E. G. "PCBs Involvement in the Pulp and Paper Industry" Final Report, Task IV (EPA 560/6-77-005). Springfield, Virginia: National Technical Information Service (NTIS PB 271-071/6WP), February 25, 1977.

*Summary included in Appendix C.

*Whitmore, F. C. "A First Order Mass Balance Model for the Sources, Distribution, and Fate of PCBs in the Environment," Final Report, Task V. (Report No. EPA 560/6-77-006), Springfield, Va.: National Technical Information Service (NTIS PB 270-220), July, 1977.

*Burruss, R. P. "Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs," Final Report, Task VI. (Report No. EPA 560/6-77-007), Springfield, Va.: National Technical Information Service (NTIS PB 270-225), July, 1977.

*Westin, R. A. "Assessment of the Use of Selected Replacement Fluids for PCBs in Electrical Equipment," Final Report, Task VII. (EPA 560/6-77-008), Springfield, Va.: National Technical Information Service (NTIS No. forthcoming).

Carr,R. A.; DeFries, R.; and Fensterheim, R. "Environmental Discharges of PCBs Associated with the Manufacture and Use of PCBs and PCB-Containing Equipment." (Contains EPA Proprietary Information, submitted to EPA Enforcement Division) October 29, 1976. Unpublished.

Dentel, S., and Kuniansky, S. "Usage of PCBs in Open and Semi-Closed Systems and the Resulting Losses of PCBs to the Environment," Draft Final Report. (Contains EPA Proprietary Information, submitted to EPA Enforcement Division). September 30, 1976. Unpublished.

Office of Water Planning and Standards: Mr. Ralph Holtje, Criteria and Standards Division

Sargent, D. L. "An Approach to Zero Water Usage and Runoff Control for First Tier PCB User Industries," Extension to Task II, June, 1976. Unpublished.

*Sargent, D. L. and Contos, G. Y. "PCBs Water Elimination/Reduction Technology and Associated Costs: Manufacturers of Electrical Capacitors and Transformers," Addendum to Final Report, Task II. (EPA 440/9-76-020) Washington, D. C.: Criteria and Standards Division, U. S. Environmental Protection Agency, July 2, 1976.

Contos, G. Y. "Recommendations as to PCB Sampling Sales and Sampling Points at Industrial Sources," Special Report. August 17, 1976. Unpublished.

*Mosbaek, E. (Jack Faucett Associates, Inc.) "Economic Analysis of Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls: Transformer, Capacitor, and PCB Manufacturing." Washington, D. C.: U. S. Environmental Protection Agency (Report No. EPA 230/1-76-068), October 1976.

*Contos, G. Y. "Costs for U.V.-Ozonation Process," Addendum to Final Report, Task II. September 27, 1976. Unpublished.

*Sargent, D. L. and Contos, G. Y., "Detailed Cost Estimates for Alternative PCBs Treatment Technologies Applied to Hypothetical Large and Medium Sized PCB Capacitor and Transformer Manufacturing Plants," Addendum to Final Report, Task II. October 15, 1976. Unpublished.

*Summary included in Appendix C.

*Contos, G. Y. "Cost for Equalization Basin Based on Bentonite Clay Liner," Special Report. October, 1976. Unpublished.

*Westin, R. A. "Impacts of Substitutes for PCBs on Fire Hazards in Commercial and Residential Buildings," Draft Special Report. Washington, D. C.: Criteria and Standards Division, U. S. Environmental Protection Agency, October, 1976. Unpublished.

*Durfee, R. L. and Hackman, E. E. "Recent Advances in PCBs Detoxification in Wastewater," Supplement to Final Report, Task II. Washington, D. C.: Criteria and Standards Division, U. S. Environmental Protection Agency, January 18, 1977. Unpublished.

*Durfee, R. L. and Carr, R. A. "PCB Levels in Non-Contact Cooling Waters and Other Effluents from Capacitor and Transformer Production Facilities," Supplement to Final Report, Task II. Washington, D. C.: Criteria and Standards Division, U. S. Environmental Protection Agency, January 19, 1977. Unpublished.

*Durfee, R. L.; Sargent, D. H. and Contos, G. Y. "Refinement of Alternative Technologies and Estimated Costs for Reduction of PCBs in Industrial Wastewaters from the Capacitor and Transformer Manufacturing Categories." Washington, D. C.: Criteria and Standards Division, U. S. Environmental Protection Agency, January 19, 1977. Unpublished.

*Durfee, R. L. and Westin, R. A. "Costs Associated with Installing Production Equipment for Use of Non-PCB Dielectric Fluids in Transformer and Capacitor Manufacture," Supplement to Final Report, Task II. Washington, D. C.: Criteria and Standards Division, U. S. Environmental Protection Agency, January 19, 1977. Unpublished.

<u>PCB Disposal and Marking Work Group: Mr. David Wagner, EPA Project Officer</u>

"Assessment Methodology for Labeling and Education to Assure the Proper Disposal of PCBs." (Outline of the technical assessment that would be required to support the regulations for the labeling of PCBs) November 1976. Unpublished.

"Analysis of the Economic and Technological Constraints on the Disposal of PCBs," Special Report, November 22, 1976. Unpublished.

"PCB Disposal Regulations: Problem Areas and Regulatory Alternatives." December 10, 1976. Unpublished.

"Estimated Usage of Electrical Equipment Containing PCBs." December 23, 1976. Unpublished.

"Recommended Label Requirements and Suggested Label Formats." January 12, 1977. Unpublished.

"Draft Notice of Public Meeting - PCBs." January 10, 1977. Unpublished.

* Summary included in Appendix C.

"Comments on PCB Definitions to Subcommittee on Manufacturing Bans." January 14, 1977. Unpublished.

"Draft Notice of Proporse Rulemaking, Preamble, and Labeling and Disposal Regulations" (Revised 2-4-77). January 21, 1977. Unpublished.

"Labeling and Disposal Regulations" Revised Draft. January 27, 1977. Unpublished.

"Draft Preamble to PCB Disposal Regulation." December 29, 1976, (Revised January 12, 1977, February 21, 1977). Unpublished.

"Economic Impact - Summary and Conclusions," (Early Draft of Marking and Disposal Economic Impact Report). March 14, 1977. Unpublished.

"Statement of Economic Consequences of the Rule" (Draft Section for Preamble to Marking and Disposal Regulation). April 12, 1977. Unpublished.

*Westin, R.A.; Fourt, L.; Drabkin, M.; Guinan, D.; Berkey, D.; Frankel, I.; and Sood, D. "Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs," (EPA 560/6-77-013). Springfield, Va.: National Technical Information Service (NTIS PB-267-833), April 1977.

*"Potential Impacts of the Bans on PCB Manufacturing, Processing, and Use: PCB Activity Analysis Papers," Special Report. July 11, 1977. Unpublished.

Westin, R.A.; Fourt, L.; Drabkin, M.; Berkey, D.; Woodcock, B.; and Sood, D. "Microeconomic Impacts of the Draft PCB Ban Regulations," Draft Report, (based on August 30, 1977 draft of regulations). September 28, 1977. Unpublished.

*Westin, R.A.; Fourt, L.; Berkey, D.; and Woodcock, B., "Microeconomic Impacts of the Draft PCB Ban Regulations," (Includes Appendices C: "Characterization of U.S. Waste Oil Industry," and D: "Supply and Demand Effects of PCB Ban on the Electric Equipment Industry."). March 8, 1978. Unpublished.

Contract 68-01-4771

Office of Planning and Management: Mr. Steven Malkenson, Mr. Stephen Weil, EPA Technical Project Officers

*Westin, R.A.; Fourt, L.; Berkey, D.; and Woodcock, B. "Microeconomic Impacts of the Proposed PCB Ban Regulations" (EPA 560/6-77-035) Springfield, Virginia: National Technical Information Service (NTIS PB-281 881/3WP), May, 1978.

*Westin, R.A.; Woodcock, B., "PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis," (EPA 230-03/79-001). Washington, D.C.: Office of Planning and Management, U.S. Environmental Protection Agency.

*Summary included in Appendix C.

Other Contracts

Whitmore, F.C. "Destruction of Polychlorinated Biphenyls in Sewage Sludge During Incineration" Final Report (EPA Contract 68-01-1587) Springfield, Virignia: National Technical Information Service (NTIS PB-258 162), 1975.

Sargent, D.H.; Carr, R.A.; and Vogel, G.A. "PCBs Removal in Publicly-Owned Treatment Works," Final Report, Task 13. EPA Contract 68-01-3273, Washington, D.C.: Criteria and Standards Division, Office of Water Planning and Standards, U.S. Environmental Protection Agency, December 15, 1976.

Versar, Inc., "Gross Annual Discharge to the Waters in 1976 - Polychlorinated Biphenyls," Revised Report No. 16, Task II. (EPA Contract 68-01-3852) Washington, D.C.: Monitoring and Data Support Division, Office of Water Planning and Standards, U.S. Environmental Protection Agency, 1978.

# APPENDIX C

## SUMMARY OF MAJOR VERSAR REPORTS REGARDING PCBs

# TOXICOLOGICAL STUDIES CONDUCTED UNDER TASK I

Special Report February 19, 1976
(Included in "PCBs in the United States..." as Appendix F)

This study presents the results of two general areas of effort concerned with PCBs: the toxicology of PCBs and the testing of potential substitutes for PCBs.

The toxicological aspects of PCBs are summarized, with emphasis placed on potential human health hazards caused by widespread use of PCBs in the United States. Tests have been conducted on the toxicity and carcinogenicity of PCBs in a variety of animals including rats, dogs, rabbits, and monkeys. In addition, there was an incident in Japan where approximately 1,000 people consumed rice oil that was contaminated with PCBs.

Reviewing the results of these studies led to several important conclusions. PCBs tend to localize in certain tissues and do not break down easily in the body, leading to cumulative or chronic toxicity. Early toxicological evidence concerning the chronic adverse health effects of PCBs from experimental animals such as mice and rats and from observational data in humans has more recently been supplemented by additional experimental findings in monkeys. A close correlation exists for PCBs between the symptoms noted in humans and those noted in monkeys, suggesting that the dose/response relationships and metabolic and excretion phenomena in humans are similar to those in monkeys. According to some pathologists, PCB exposure can cause cancerous liver lesions. Evidence from short-term (several months) exposure and chronic exposure in animals and humans demonstrates that PCBs are a significant health hazard.

Following the review of the toxicological potential of PCBs, a study was made of the procedures necessary for evaluating the potential hazards from possible PCB substitutes. Preliminary information necessary for a thorough investigation of a substance includes:

1) Physical and chemical properties
2) Manufacturing processes and possible losses
3) Chemodynamics, environmental alteration, and bioaccumulation.

# PCBs IN THE UNITED STATES: INDUSTRIAL USE AND ENVIRONMENTAL DISTRIBUTION

FINAL REPORT, TASK I

February 25, 1976

EPA 560/6-76-005
NTIS PB-252-012

TABLE OF CONTENTS

This report summarizes the production, use, and distribution of polychlorinated biphenyls (PCBs) in the United States. The information was obtained by detailed studies of the production of PCBs, the use of PCBs by first tier user industries, the past and present generation and disposition of PCB-containing wastes, environmental transport and cumulative loads, potential alternatives to PCB usage, inadvertent losses to and potential formation of PCBs in the environment, and current regulatory authorities for PCBs control.

It is estimated that approximately 1.5 billion pounds of PCBs have been sold for industrial use in the U. S. since initiation of production around 1930. Of this amount, at least 95 per cent is still in existence; most is in service in capacitors and transformers, but about 290 million pounds are believed to reside in landfills and dumps and about 150 million pounds are believed to be "free" in the environment. The magnitude of these values indicates that there is a strong future threat from PCBs in land disposal sites.

In 1974, U. S. use of PCBs sold by Monsanto, the sole domestic producer, was distributed between capacitor manufacture (22 million pounds) and transformer manufacture (12 million pounds). Imported materials amounted to about one per cent of U. S. industrial purchases of PCBs in 1974; about 400,000 pounds (of decachlorobiphenyl) were used in investment casting, and an estimated 50,000 pounds of new material were used in specialized heat transfer systems.

Although PCB content in industrial wastes can be reduced through various approaches (treatment, substitution, etc.), the large amounts of PCBs already contained in land disposal sites present a severe hazard for the future. Further study of this and other aspects of the PCBs problem, and determination of ways to minimize the hazard, are recommended.

Monsanto and portions of the electrical equipment industry which use PCBs have greatly reduced PCB releases to water and land over the past few years, primarily through improvement of plant housekeeping, improved waste collection and handling, and disposal of liquid wastes through incineration. Waterborne effluents from PCBs production and first-tier use currently release amounts to the environment which are very small in comparison to the amounts entering land disposal sites from these industries. However, these effluents can have severe local impacts, as evidenced by the current PCB problem in the Hudson River.

There is no plant-scale process used at present for the specific purpose of removing PCBs from industrial wastewater. The best available treatment technology for removal of PCBs from wastewater is carbon adsorption after removal of solids, oil, and grease. Carbon treatment can produce end-of-pipe PCBs concentrations of one ppb or less. Other adsorbents, such as resins, also appear effective to this extent. The most promising method of those water treatment technologies under development for PCBs destruction is ultraviolet-catalyzed ozonation. "Zero discharge" to water of PCBs from production and first-tier use is available only through extensive water reuse plus extensive incineration of lightly contaminated wastewaters.

Incineration is an effective method of disposal for liquid PCBs. Landfilling is the only generally available disposal method for PCBs-contaminated solid wastes, but incineration of these wastes is technically feasible.

Significant amounts of solid PCB (decachlorobiphenyl, or deka) wastes are stored or disposed of on land by the investment casting industry. Air emissions of deka may also be significant in amount, but no evidence of potential health hazards from this material has been reported.

The total present use of PCBs for open and semi-closed applications is not known but is believed to be small in comparison to closed electrical system use. A few capacitor manufacturing plants report recent use of PCBs in vacuum pumps, and a significant amount of carbonless copy paper containing PCBs must still be in inventory and in files.

PCBs are uniquely suited to the requirements of capacitors for A. C. service. Although a number of potential substitues for this application are under development and test, they are all more flammable than Aroclor 1016 and neither their performance in service nor their potential toxicity to man and other species have been evaluated sufficiently to allow a definitive comparison with 1016.

Alternatives to PCB use in new transformers are available. In addition, testing of promising substitute fluids (termed "self-extinguishing") is under way; these fluids may gain industry-wide acceptance within three years as substitutes for PCB fluids. At present, choice of PCB-filled transformers appears to be based primarily on cost considerations.

No technical barriers to substitution for PCBs (deka) in investment casting waxes are apparent. Several potential alternatives have been previously used by this industry.

Atmospheric fallout is a major source of PCB input to freshwater systems. In Lake Michigan, the PCB contribution at present appears to be much larger than the total PCB inputs from point sources such as minicipal sewage treatment and paper recycling.

The importance of atmospheric transport of PCBs relative to other potential inputs to water indicates that the availability of environmental sinks from PCBs is limited, possibly due to short residence times to evaporation in sea water.

Chlorination of waste biphenyl in industrial wastewaters discharged into municipal sewers is a potential mechanism for inadvertent production of PCBs.

At present, regulatory authority over PCBs in the United States is not sufficient to significantly reduce future PCB inputs to the environment, although inputs directly to the waterways from industrial sources can be reduced from their present level. Current disposal practices, except for incineration, tend to delay instead of prevent the PCB entry into the "free" (available to the biota) state, and these practices are regulated only minimally.

# DEVELOPMENT OF AN ECONOMIC ANALYSIS METHODOLOGY FOR EVALUATING REGULATORY ALTERNATIVES FOR PCBS

Task I, Special Report March 9, 1976

(Prepared by Jack Faucett Associates under Subcontract to Versar)
Unpublished

This report presents factors to be taken into account when evaluating alternatives to PCBs to arrive at fair and reasonable time restrictions on the use of PCBs. Also included are a critique of previous estimates of the cost of regulating PCBs, suggestions for improving such estimates, and a survey of the technological aspects of PCB controls.

The following regulatory alternatives are considered:

1) Regulation based primarily on chlorine content of Aroclor
2) Regulation based primarily on type of use
3) Regulation based on responsibility of user
4) Regulation of new PCBs
5) Regulation of phase-out for PCBs currently in use
6) Regulation oriented toward control of waste
7) Regulation oriented toward protection of population from exposure to PCBs

After possible regulatory options were identified, a study was made of the information required to evaluate the various alternatives. It was decided that comprehensive information in each of the following areas was needed:

1) Present manufacturing and use
2) Future substitutions and product changes
3) Methods of release to the environment and transport and fate in the environment
4) Toxicity, including exposure levels and results of past incidents
5) Effect, legality, and options for regulation

Covered under the study of technological aspects of PCB controls are:

1) Current and suggested regulations for reducing exposure to PCBs currently in the environment

2) Waste disposal control
3) Effects of phasing out PCB use
4) Limitations on the use of new PCBs in investment casting wax, small capacitors, large power factor capacitors, and electrical transformers

Factors that were analyzed for each of the products above are:

1) Risks from continued use
2) Present alternatives
3) Effect that timing of a ban would have on cost and availability of alternatives
4) Benefits from use of alternatives
5) Cost of ban of PCBs

This report reaches the following conclusions:

1) A total ban on PCBs will have only a minor effect on the current environmental problem but will be necessary in the long run.
2) The smooth transition to PCB alternatives is unlikely because of uncertainty about the rationale for and probability of a PCB ban.
3) Many of the opinions and cost estimates uncovered in this research indicate that there has been more preparation for debate than for orderly changeover
4) Estimates of costs and benefits should be clearly explained to provide incentive for every accurate data supply.

# ASSESSMENT OF WASTEWATER MANAGEMENT, TREATMENT TECHNOLOGY, AND ASSOCIATED COSTS FOR ABATEMENT OF PCBs CONCENTRATIONS IN INDUSTRIAL EFFLUENTS

FINAL REPORT, TASK II

February 3, 1976

EPA 560/6-76-006

NTIS 251-433/AS

## TABLE OF CONTENTS

This report presents the findings of a study of available wastewater management and treatment technology for the purpose of determining toxic pollutant effluent concentrations and daily load achievable in three industrial categories: polychlorinated biphenyls (PCBs) manufacturing; capacitor manufacturing; and transformer manufacturing. All plants in these categories have PCB discharges to either waterways or sewage treatment plants, under normal operating conditions. All plants have discharges to storm sewers or directly to waterways under heavy rainfall conditions.

Extensive survey of wastewater treatment technologies and cooperative laboratory work with several suppliers of treatment equipment and research facilities confirmed that carbon adsorption technology is the best current candidate for successful removal of PCBs from the wastewaters. Uv-ozonation was considered as an alternative. This technology is still in the research stage; however, it offers potential of complete destruction of PCBs all the way to $CO_2$, water, and HCl.

Another adsorbent technology now in the development stage, AMBERLITE polymeric adsorbents, has demonstrated a PCBs removal efficiency that was roughly equivalent to carbon during laboratory tests. Further testing is needed with this adsorbent to accurately assess its potential.

For scrap oils and burnable solid wastes generated at these plants, high temperature, controlled incineration offers a straightforward method of destruction, whereas scientific landfilling appears to be the best suited mode of disposal for nonburnable contaminated solids.

Zero discharge objectives can be best achieved by eliminating discharge streams and developing recycle systems. All non-contact cooling water would be pretreated. The portion of the pretreated water which would be used in the plant would be treated with carbon, while the excess water would be incinerated in a specially designed system which would allow for energy recovery.

Supporting data, rationale for the selection of above recommended treatment technologies and associated costs are contained in this report.

# DEVELOPMENT OF A STUDY PLAN FOR DEFINITION OF PCBs USAGE, WASTE, AND POTENTIAL SUBSTITUTION IN THE INVESTMENT CASTING INDUSTRY

FINAL REPORT, TASK III

JANUARY, 1976

EPA 560/6-76-007

NTIS PB 251-842

This report summarizes the use of decachlorobiphenyl (deka) and polychlorinated terphenyls (PCTs) as wax fillers in the investment casting industry and develops a detailed study plan of the industry. Significant information gathering efforts would be required to establish a complete picture of the practices, processes, and products of this industry, which in this instance, is taken to include casting wax manufacture as well as wax usage in foundries. Definition of the waste streams and emissions from the processes used will require sampling and analysis and gathering available process data from the industry.

An approach to determining the most suitable alternatives to decachlorobiphenyl and PCTs is presented. Filler substitutes and the use of unfilled waxes are the two general alternatives to be studied. At present there appear to be no technical barriers to discontinuation of deka and PCTs as fillers, although use of alternatives may increase product cost on the order of 10 percent. In determining the most promising alternatives, product and process oriented technical factors must be evaluated, but potential environmental and human health effects may prove to be the most important factors in selection. An approach to comparison of alternatives based on technical factors and toxicology data is presented. However, it is anticipated that toxicological data on most alternatives, and also on the currently used materials, will be sparse.

The success of information gathering and in-plant sampling efforts is expected to depend heavily on use of Section 308 (FWPCA) authority. Air emission sampling would be very important to the establishment of an overall process material balance and definition of process losses to the environment.

PCBS INVOLVEMENT IN THE PULP AND PAPER INDUSTRY

FINAL REPORT, TASK IV February 25, 1977 EPA 560/6-77-005

NTIS PB-271 017/6WP

This paper discusses in detail the sources, distribution, and losses of PCBs in the U. S. pulp and paper industry. The major use of PCBs in the industry was as an ink solvent in carbonless copy paper that was manufactured by various paper mills for NCR from 1957 to 1971. Since 1977, PCB levels in recycled paper have diminished rapidly but PCBs are still present in the effluent water from companies that recycle waste paper.

Aroclor 1242, a PCB mixture containing 42% chlorine, was used as a solvent for color reactants which were then microencapsulated and applied to one side of the carbonless copy paper. The microspheres ruptured and released the dye under high pressure, such as would be applied by a pen or pencil. 44,162,000 pounds of Aroclor 1242 were used for this purpose during the period 1957-1971. The average content of PCBs in the paper was 3.4%. A minor use of PCBs in the paper industry, was in inks, which consumed approximately 50,000 pounds of PCBs from 1968 to 1971.

Recycling of wastepaper is a large part of the paper industry. Wastepaper is the third most important source of pulp behind pulpwood and forest product wastes. 19% of the annual output of finished paper is recycled each year. There are 230 paper mills that produce pulp completely derived from wastepaper and 550 other facilities that use 10-15% secondary fiber in their pulp production.

PCB concentrations in paper products, paper mill effluents, and sludges have declined sharply since the use of PCBs in carbonless copy paper was terminated in 1971. Concentrations in paper products are now in the 0-1 ppm range. Sludges have been in the < 1 to 24 ppm range which is common for municipal sewage treatment plants. The major reasons behind this sharp reduction in PCB concentrations are the elimination of PCB use and the disposal each year of 81% of the annual, paper production via incineration or landfilling; together these removed approximately 80% of the PCBs from the paper cycle each year. A small amount of PCBs is added to paper products each year because of the presence of PCBs in plant influent water, but this contribution does not appear to be significant at present.

Prediction of PCBs in paper mill effluent and products by using a mathematical model of the industry indicates that PCB concentration reached its peak during 1970-71 and is declining to pre-1957 levels because amounts of PCBs in the recycled wastepaper stream are also declining.

On-site measurements and laboratory experiments have shown that PCBs are attracted to the fibers rather than to the water in which they are carried. Discharge of PCBs from a paper mill appears to be by way of suspended solids and removal of these suspended solids should substantially reduce PCB effluents.

The paper industry as a whole is continuing to develop and install water recycling technology in order to minimize waste treatment costs and recover chemicals, heat, and raw materials. New treatment systems also offer the promise of reduced PCB discharges. Some data indicate that PCBs are being removed from influent streams and are becoming fixed in the paper products, thereby producing a net reduction in PCBs which are free in the environment. However, these PCBs could be re-released when the paper products are disposed of.

It is believed that essentially all of the PCBs used in the production of carbonless copy paper have been released to the environment. Half are believed to reside in landfills and the remainder have been dissipated.

# A FIRST ORDER MASS BALANCE MODEL FOR SOURCES, DISTRIBUTION, AND FATE OF PCBs IN THE ENVIRONMENT

FINAL REPORT, TASK V

JULY, 1977

EPA 560/6-77-006

NTIS PB 270-220

The work presented here, an extension of that reported in the Task I report, is an attempt to answer the question, "How did it come about that a compound, such as the PCBs, is so widespread an environmental contaminant?" The work involves the construction of several descriptive mathematical models made necessary by the lack of historical data and the absence of a large base of reliable contemporary measurements. The work is necessary since the measurements that do exist strongly suggest that the PCBs are a persistent menace to the biosphere and hence that actions to control them cannot be delayed while a truly adequate data base is obtained.

The basic model is constructed on a mass balance principle; that is, all the PCB input to a restricted region of the lithosphere may be accounted for by solution, by uptake on suspended solids, and by uptake within the biota, with the remainder of the input PCBs being carried off by the "loss" processes consisting of surface co-distillation, carryoff by outflowing streams, and entrapment within the sediments.

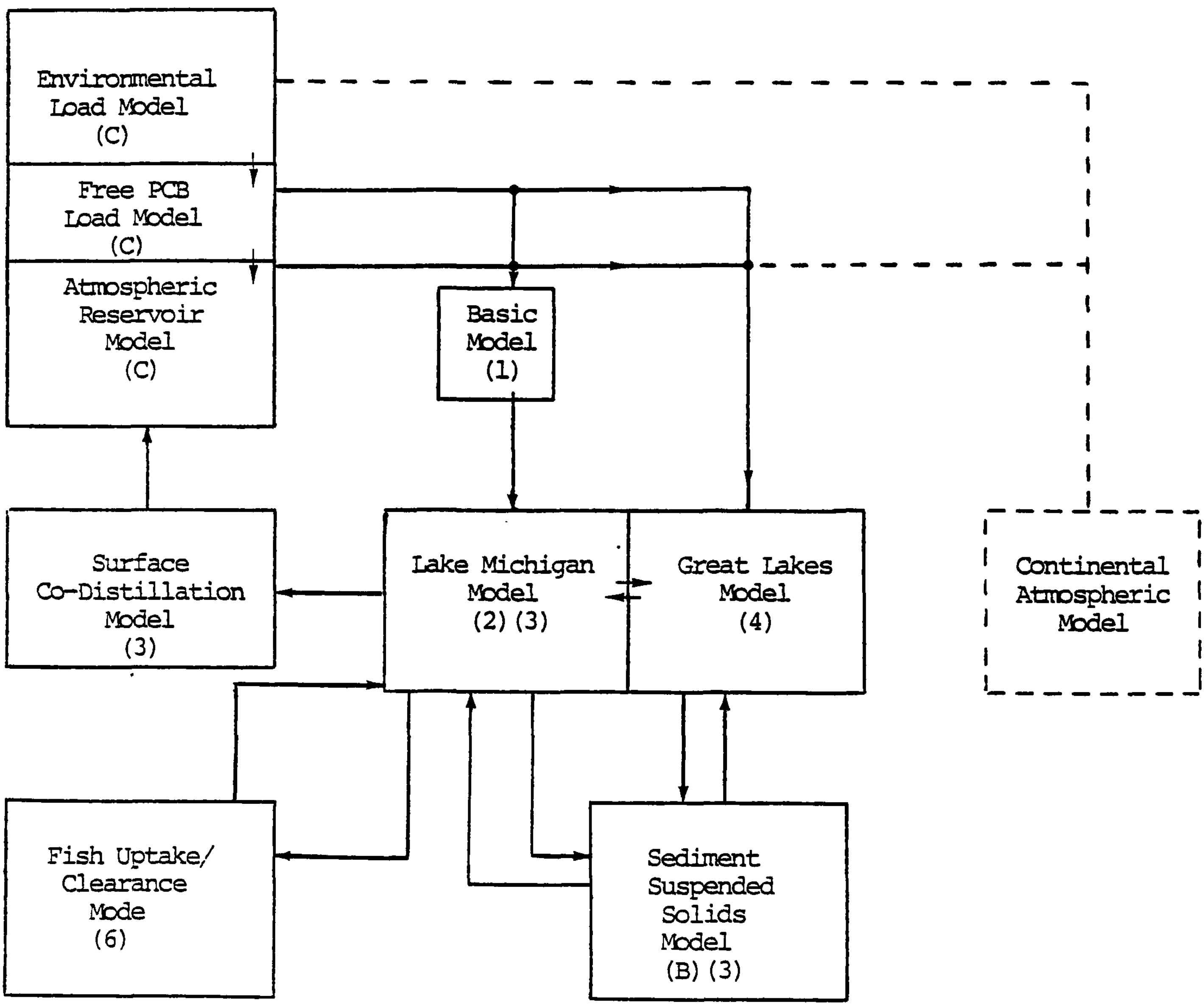
The model is somewhat complicated by the necessity of an analytic expression for the PCB input rate as a function of time; i.e., the driving function. In the absence of a sufficient amount of data, a model has been constructed to account for the losses to the environment, for the free or "wild" PCB load, and for the atmospheric reservoir of PCBs. The actual relationship of the various parts of the model are shown in Figure I.

## Environmental Load Model

Appendix C and Appendix D attempt to determine the magnitude of the total environmental load, the free environmental load, and the atmospheric reservoir of PCBs, all as functions of time.

Figure I

Schematic Showing Relationship of the Various Sections of Report*




*The number or letter associated with each block refers to section dealing directly with the subject matter.

The results of this analysis are:

a. In 1975, the total environmental PCB load is estimated to be 3.76 x $10^8$ lbs. within the continental United States.

b. In 1975, the total free or mobile PCB load in the continental United States is estimated to be 8.31 x $10^7$ lbs. The remainder of the total environmental load is thought to be encapsulated in one form or another (in landfills, for example).

c. As of 1970, the cumulative atmospheric reservoir contained some 6 x $10^7$ lbs. of PCB indicating a rather rapid exchange between the total mobile PCBs and the atmospheric reservoir.

d. As of 1975, the PCB concentration in the air near Lake Michigan was of the order of 10 $\mu g/m^3$.

e. The estimated half life for fallout from the atmospheric reservoir is 0.9 years.

f. The average chlorine number for environmental PCBs is of the order of 4.32.

<u>Results of Mass Balance Model Applied to Lake Michigan</u>

The results of this analysis are:

a. A plausible scenario indicates a present-day PCB concentration (water plus suspended solids) of the order of 7-10 ppt.

b. Atmospheric fallout constitutes the major input of PCBs to Lake Michigan.

c. Surface evaporation or co-distillation (the exact nomenclature is not known because the process is incompletely understood) constitutes a significant PCB loss mechanism.

d. The presence of suspended solids within the water column can be expected to have a dominant effect on the actual (filtered) aqueous concentration.

e. The sediments should act as a significant sink for the removal of PCBs from the water column.

f. Even though there is considerable uncertainty as to the proper value for some of the important parameters, the sheer bulk of the water mass makes the aqueous concentration essentially independent of these parameters over wide ranges.

g. 70 years would be required to reduce the present PCB concentration by one-half in the absence of all external sources.

Results of Mass Balance Model Applied to the Entire Great Lakes System

a. A plausible scenario leads to an estimate of aqueous PCB concentrations within the range of measured values, i.e., less than 40 ppt.

b. The estimated average PCB concentration in the sediments of Lake Erie and Lake Ontario fall within an order of magnitude of other estimates.

c. The estimated fallouts in 1974 onto Lake Erie and Lake Ontario both fall within a few percent of other estimates.

d. Point source inputs, when introduced into Lake Erie and Lake Ontario, led to PCB concentrations in the aqueous phase as well as within the sediments which are within a factor of 2 or 3 of direct observation.

e. The lifetime of the present PCB loads in the absence of all sources can be estimated.

Other Results

Other results obtained somewhat incidentally to the main effort include:

a. An estimate of the bioconcentration rates of PCBs for a trout (about $4 \times 10^6$).

b. An estimate that, for the trout, the uptake of PCBs from contaminated food is 50 times greater than from respiration.

c. The MacKay and Wolkoff model for co-distillation is apparently not applicable in the situation where infalling PCB complicates the situation.

d. The significant difference in activity of PCBs in bulk solution compared to that in the surface layer is probably the driving force for the creation of a surface concentration gradient.

e. A formulation is developed that suggests the possibility of an analysis of the continental PCB atmospheric reservoir.

ASSESSMENT OF THE ENVIRONMENTAL AND ECONOMIC
IMPACTS OF THE BAN ON IMPORTS OF PCBS

FINAL REPORT, TASK VI

JULY 1977

EPA 560/6-77-007

NTIS PB 270-225

This report summarizes an investigation into the uses of imported PCBs in the United States and a determination of the economic impacts which may occur as a result of the impending ban on importing PCBs. Imported PCBs are currently used only for the maintenance of two types of mining machinery produced in the past by Joy Manufacturing Co. PCBs may also be a significant contaminant in polychlorinated terphenyls (PCTs) which wax manufacturers import for use in tooling compounds and investment casting waxes. However, the sole U.S. distributor of PCTs is currently guaranteeing that such contamination is less than 0.05%.

PCB fluids were used as coolants in mining machinery because of their low combustability, low electrical conductivity, and inertness which minimizes system corrosion even at continuous high operating temperatures. The two types of mining machinery manufactured by Joy which use PCBs are loaders, of which there are approximately 350 and which were last produced in 1973, and continuous miners, of which there are approximately 50 and which were last produced in 1970. Converting the motors in the loaders to air cooling would cost about $6,200 per loader. Converting the continuous miners would require replacement of the cutting heads and would cost about $65,000 per miner. As a result of the Toxic Substances Control Act, owners of the machinery which use PCB fluids have three options:

1) Petition for an exemption to the Act.
2) Bear the cost of converting the machinery motors to air-cooling.
3) Scrap the machinery.

PCTs are used in wax formulations known as tooling compounds, which are used to provide support to thin walled objects so that they may be machined without being damaged. After machining, the tooling compound is removed either by melting or by using an aqueous acid solution. The sole producer of tooling compounds which contain PCTs is M. Argueso & Co. of Mamaroneck, N.Y.

Investment casting is a method of producing metal castings which may have complex shapes and which have a surface finish and dimensional tolerance which cannot be matched by other casting processes. It involves first making a pattern out of wax; the pattern is then covered, or "invested," with a refractory coating which hardens at room temperature. The wax is then melted and/or burned out of the mold. The metal is then poured in and allowed to harden. Investment casting is best suited to the production of a large volume of small, intricate parts made of metals which are difficult or impossible to machine.

PCTs are used in investment casting waxes for several reasons. They make the wax harder at all temperatures below the melting point; they cause the wax to harden faster by improving thermal conductivity; and they reduce the coefficient of thermal expansion of the wax, resulting in improved dimensional accuracy in the finished casting. Detailed data on PCT loss to the environment is not available, but possible sources of loss include mold production, mold dewaxing, mold firing and preheating, and wax reclamation. There are eleven manufacturers of investment casting waxes in the United States; three currently use PCTs in their formulations, and three others did in the past but no longer do so. All three current users of PCBs receive them from the same distributor.

The following points with respect to PCT use in tooling compounds and investment casting waxes are noted:

1) PCT containing casting waxes cost 15¢ to 25¢ per pound more than non-PCT containing waxes and comprise less than half of the total sales of manufacturers who sell them.
2) Of the three manufacturers of PCT containing waxes who ceased using PCTs in their waxes within the past decade, none seems to have been placed in an unfavorable competitive position.

3) One investment casting foundry, General Electric, has ceased using PCT waxes. They have apparently found adequate substitutes for use in casting turbine blades, an application which is critically dependent upon high dimensional accuracy and extremely fine surface finish.
4) From 2 and 3 above, it appears that acceptable substitutes for PCT-containing waxes are available.
5) If imported PCTs are found to contain PCBs in excess of 0.05%, the EPA can take action to ensure adequate quality control.
6) If PCTs are found to "present an unreasonable risk of injury to health or the environment," they may be banned.

### ASSESSMENT OF THE USE OF SELECTED REPLACEMENT FLUIDS FOR PCBs IN ELECTRICAL EQUIPMENT

Final Report, Task VII, April 1979 EPA 560/6-77-008

NTIS No. Forthcoming.

This report discusses the use of PCBs as dielectric liquids in transformers, motors, electromagnets, and capacitors. The performance criteria for replacement liquids are summarized and alternative technologies are reviewed.

The major alternatives to the use of PCBs in tranformers are:

- Dry type transformers, including gas-filled and cast coil construction
- Oil-filled transformers located in safe locations or installed in a vault
- High fire point liquid dielectric-filled transformers, including silicone, paraffinic hydrocarbon, and synthetic hydrocarbon liquids
- Non-PCB askarel liquids based on chlorinated benzenes

PCB filled electromagnets may be replaced with available oil-filled, high-fire point liquid-filled, or dry type units. Dry air-cooled motors are also available for most of the previous applications using PCB-filled electric motors.

Alternative capacitor liquids are:

Phthalate esters
Alkylated monochlorodiphenyl oxide
Isopropyl biphenyl

Other possible capacitor dielectric liquids are also discussed, and the status of dry film capacitors is reviewed.

PCBs WATER ELIMINATION/REDUCTION TECHNOLOGY AND ASSOCIATED COSTS, MANUFACTURERS OF ELECTRICAL CAPACITORS AND TRANSFORMERS

ADDENDUM TO FINAL REPORT, TASK II

JULY 2, 1976

EPA 440/9-76-020

The general potential for reduction of water use in the electrical equipment manufacturing industry is favorable, since water has to be carefully excluded from the internals of both transformers and capacitors for the units to meet product and performance specifications. Newer plants in these categories, particularly those of smaller size, use much less water per unit of PCB use than the older plants. However, the existing plants would require a combination of process and plant modifications and wastewater treatment and recycle to achieve a goal of no discharge of PCB-contaminated waters. This addendum to the Task II report summarizes the quantities and sources of the wastewaters; describes the available alternative technologies for reducing or eliminating the discharges on a source-by-source basis; and tabulates the estimated costs for achieving such reduction or elimination.

Section 2.0 of this report addresses the point sources from the capacitor and transformer manufacturing industry with the absolute goal (with a single exception from one plant) of no point-source discharges of any waters. Extensive applications of process changes (from wet to dry unit processes or unit operations), of water segregation practices, of water treatment and recycle practices, and of water-quantity reduction practices were investigated. The residual contaminated wastewaters not eliminated by these practices were then hypothesized to be "incinerated," e.g., heated to a sufficiently high temperature for a sufficiently long time to ensure destruction of PCB contaminants.

Section 3.0 presents the technologies and costs for eliminating PCB contamination of rainwater runoff from manufacturing plants in this industry.

Section 4.0 presents the technical basis and estimated costs for three alternative approaches to PCBs reduction in the direct discharges from this industry to waterways. The technology and costs presented are based on those of Reference 1 and Sections 2.0 and 3.0 of this Addendum. The approaches were selected to offer a range of PCBs control at various levels of costs.

The estimated costs are as accurate as was possible within the scope of work. Based on previous experience in this area, we feel that the least reliable costs tabulated are those for waste stream segregation. Costs for segregation are highly variable from plant to plant, and accurate estimation is only possible as a result of detailed study of plant layout, piping, etc., which was beyond the scope of this study.

ECONOMIC ANALYSIS OF PROPOSED TOXIC POLLUTANT EFFLUENT STANDARDS FOR POLYCHLORINATED BIPHENYLS; TRANSFORMER, CAPACITOR, AND PCB MANUFACTURERS

October 1976 EPA 230/1-76-068

(Prepared by Jack Faucett Associates Under Subcontract from Versar)

This report presents an assessment of economic impacts from PCB effluent controls. Because of the cost of required effluent controls, it is estimated that a minimum of nine and maximum of all eleven direct discharging plants will stop using PCBs depending on the particular regulation issued. According to industry opinion, the estimated minimum is very unlikely because additional PCB controls would encourage stopping use of PCBs. Decisions against investment in control equipment does not mean, however, that the impacts of these regulations are zero. Company decisions to cease PCB use will have impacts, particularly with regards to the timing of the decision to stop using PCBs. The earlier the switch to substitutes the more likely that product prices and performance will change in the transition.

There is evidence that some industries will cease PCB use prior to implementation of Section 307(a) controls. That evidence is based on investment analysis of probable effects on company profits, announced decisions such as those by General Electric and Monsanto, and capacitor/transformer users' preparations for PCB substitutes. These decisions are significant in light of the range of government alternatives that were considered. A major force in government controls affecting PCB use is the Toxic Substances Control Act, which will prohibit the use of PCBs in capacitors and transformers by 1980. The EPA proposed toxic pollutant effluent standards for PCBs in July 1976, and EPA is scheduled to promulgate regulations in January 1977. Depending on the final standard, the affected plants which continue PCB use are likely to install one of the treatment technologies presented below. Circumstances at each plant could cause deviations in technology costs from the following summaries:

| Government Regulatory Options | Potential Technology | Average Investment Cost/Plant |
|---|---|---|
| A | Process Change & Carbon Treatment | $ 527,000 |
| B | Maximum Carbon Treatment | $1,207,000 |
| C | Minimum Carbon Treatment | $ 392,000 |
| Zero Discharge | Process Change and Recycle | $ 555,000 |

The cost of each of the technologies varies considerably among plants, but the above costs are an average of investment costs for model plants that were considered.

Since few if any plants will actually install effluent control equipment in response to Section 307 (a) directly, economic impacts can be viewed as emanating from timing of decisions. Monsanto's voluntary ban on PCB production and the new Toxic Substances Control Act will effectively terminate PCB use by 1980 independent of Section 307 (a) provisions.

Total investment costs and total annual costs for each of the four treatment technologies are given in the table below. Our analysis focuses on the 11 direct discharging plants of the 37 plants that manufacture PCB transformers and capacitors.

The following summaries are based on analysis of investment, i.e., investment to meet only federal effluent controls under Section 307 (a), for model plants. Conclusions on whether companies with plants similar to each model would actually install the specified treatment are based on a comparison of present costs of the equipment.

INVESTMENT AND ANNUAL COSTS FOR DIRECT DISCHARGING TRANSFORMER AND CAPACITOR PLANTS

(Millions of Dollars)

| | Required Treatment | | | |
|---|---|---|---|---|
| | A | B | C | Zero Discharge |
| Number of Plants that would Install Treatment: | | | | |
| Transformer | 0 | 0 | 0 | 0 |
| Capacitor | 1 | 0 | 2 | 1 |
| Total Investment:[a] | | | | |
| Transformer | 0.0 | 0.0 | 0.0 | 0.0 |
| Capacitor | .26 | 0.0 | .23 | .31 |
| Total Annual Cost: | | | | |
| Transformer | 0.0 | 0.0 | 0.0 | 0.0 |
| Capacitor | .14 | 0.0 | .10 | .19 |

a) Investment analysis indicates an acceptable return on investment.

## Alternative A Treatment Costs

EPA standards which would lead firms to invest in Alternative A would cause 5 direct discharge capacitor plants and all 5 direct discharge transformer plants to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. The one remaining direct discharging capacitor manufacturer could comply with the regulation by installing the necessary treatment equipment. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 35 percent and of PCB transformers by about 50 percent. Industry-wide investment for control equipment would be $ .26 million with annual costs of $ .14 million.

## Alternative B Treatment Costs

EPA standards which would lead firms to invest in Alternative B would cause all capacitor and transformer plants among the direct discharges to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 45 percent and of PCB transformers by about 50 percent.

## Alternative C Treatment Costs

EPA standards which would lead firms to invest in Alternative C would cause 4 direct discharge capacitor plants and all 5 direct discharge transformer plants to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. The two remaining direct discharging capacitor manufacturers could comply with the regulation by installing the necessary treatment equipment. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 30 percent and of PCB transformers by about 50 percent. Industry-wide investment for control equipment would be $ .23 million with annual costs of $ .10 million.

## Zero Discharge Treatment Costs

EPA standards which would lead firms to invest in zero discharge would cause all but 1 direct discharge capacitor plant and all 5 direct discharge transformer plants to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. The one remaining direct discharging capacitor manufacturer could comply with the regulation by installing the necessary treatment equipment. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 35 percent and of PCB transformers by about 50 percent. Industry-wide investment for control equipment would be \$ .31 million with an annual cost of \$ .19 million.

The following economic impacts for the eleven direct discharge plants are based on industry trends as well as data collected from transformer and capacitor users and producers directly.

Average transformer price increases due solely to PCB effluent controls will be minimal because (1) PCBs used by direct discharge plants represent less than 10 and possibly only 5 percent of total transformers and (2) other expected controls and voluntary bans will already have caused a further shift to non-PCB units. The price adjustment for the less effective non-PCB transformers could be significant, but little of this increase can objectively be attributed to Section 307 (a) controls.

The dollar value of all transformer sales is likely to increase more because of higher costs with PCB substitutes than they decrease because of demand response to higher prices. However, recent data indicate that an increase in imports could easily offset any increase from higher prices, leaving domestic producers with slightly lower dollar sales.

Industry-wide capacitor price increases due solely to changes resulting from PCB effluent controls are likely to be less than 5 percent in 1977 and to decrease to less than 2 percent as PCB substitute technology improves by 1980. All environmental controls combined can generate up to a 20 percent increase in average capacitor prices. However, only part of that increase can be attributed to Section 307 (a) effluent controls which will affect only six specific plants in the entire 19 plant capacitor industry. The remaining plants will be covered by a future regulation, however.

There are no significant effects on energy consumption, balance of payments, or employment. The announced and apparent shifts to non-PCB units and the expected demand for capacitors and transformers are likely to increase rather than decrease sales and industry-wide employment. However, to prevent losses to foreign competition, domestic producers might have to absorb some cost increases in lower profits. Since all of the affected plants are either part of a much larger company or have a reasonably good PCB alternative, reduced profits will not necessarily lead to significant reductions in employment. There will be no reductions if sales in fact do increase and if similar numbers of people are needed to manufacture non-PCB units.

# COSTS FOR UV - OZONATION PROCESS

Addendum to Final Report, Task II September 27, 1976

The costs presented in the Task II Final Report were reevaluated based on new tests that determined that complete removal of the organic content in wastewaters is not required prior to removal of the PCBs.

Comparison of the terminal treatment capital costs of UV-ozonation systems with carbon adsorbtion systems for reducing the concentration of PCBs in effluent waters to below 1 ppb indicated a greater than 50% higher cost for ozone system over the carbon system. However, combining the pre-treatment costs with the terminal treatment costs results in UV-ozonation system costs about 5 to 10 percent higher than the carbon system costs.

# DETAILED COST ESTIMATES FOR ALTERNATIVE PCBs TREATMENT TECHNOLOGIES APPLIED TO HYPOTHETICAL LARGE AND MEDIUM SIZED PCB CAPACITOR AND TRANSFORMER MANUFACTURING PLANTS

Addendum to Final Report, Task II October 15, 1976

The three treatment alternatives for which costs were estimated are:

A) Process and plant modifications and pretreatment of process water.

B) Maximum use of carbon adsorption.

C) Minimum treatment.

The estimates for these three alternatives are:

| | | Large Plant 2,500,000 lbs. PCB use/yr. | Medium Plant 500,000 lbs. PCB use/yr. |
|---|---|---|---|
| Alternative A | Capital Investment | $1,997,900 | $647,000 |
| | Annual Cost | 528,900 | 164,700 |
| Alternative B | Capital Investment | 3,811,400 | 935,500 |
| | Annual Cost | 922,900 | 222,300 |
| Alternative C | Capital Investment | 1,588,400 | 575,500 |
| | Annual Cost | 374,000 | 138,200 |

## COST FOR EQUALIZATION BASIN BASED ON BENTONITE CLAY LINER

Special Report October 1976

The capital cost for the equalization basin with a bentonite clay lining is shown below. This cost was estimated based on a basin volume of three times the design flow, 24 hour residence time, and $5.00 per cubic yard of excavation cost consistent with the Task II report basis for the reinforced concrete equalization basin. The report also summarizes total installed costs, maintenance costs, and operating costs, and compares these costs to those estimated for concrete storage basins described in the Task II Final Report.

Bases:
1. 24 hour retention
2. 3 times normal flow
3. Bentonite lining at 80 tons/acre and lining cover @ $\$0.3/yd^2$
4. 12 ft depth
5. 10 ft water depth
6. L/W - 2.0

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Flow (gpm) | 20 | 40 | 80 | 160 | 320 | 640 | 1700 |
| Liquid Vol. (1000 gal) | 86 | 176 | 345 | 690 | 1380 | 2760 | 7340 |
| Width (ft) | 24 | 34 | 48 | 68 | 96 | 136 | 222 |
| Length (ft) | 48 | 68 | 96 | 136 | 192 | 272 | 444 |
| Excavation Cost ($1000) | 2.6 | 5.1 | 10.2 | 20.5 | 41 | 82 | 218 |
| Lining & Cover Cost ($1000) | 0.5 | 0.7 | 1.3 | 2.3 | 4.1 | 7.6 | 18.4 |
| Total Basin Cost ($1000) | 3.1 | 5.8 | 11.5 | 22.8 | 45.1 | 89.6 | 236.4 |
| Pumps & Sump ($1000) | 20 | 20 | 21 | 22 | 27 | 32 | 42 |
| Total Basin & Pump Cost ($1000) | 23.1 | 25.8 | 32.5 | 44.8 | 72.1 | 121.6 | 278.4 |

# IMPACTS OF SUBSTITUTES FOR PCBs ON FIRE HAZARDS IN COMMERCIAL AND RESIDENTIAL BUILDINGS

(Draft) Special Report October, 1976

This report reviews the technologies that were being developed for the replacement of PCBs as dielectric liquids in transformers and capacitors. All of the potential substitute liquids are more flammable than PCBs, and this flammability presents a potential fire hazard. The report reviews the changes in design and the effects of changing fire codes and insurance underwriter's requirements on limiting the potential hazard resulting from the use of substitutes for PCBs in electrical equipment.

The report concludes that there is no basis to assume that properly engineered and tested equipment would result in an increase in risk. Any safety problems that occur may be the result of inadequate testing and evaluation prior to commercial introduction of the electrical transformers and capacitors that use the substitute materials.

RECENT ADVANCES IN PCBs DETOXIFICATION IN WASTEWATER
Supplement to Final Report, Task II

January 8, 1977

This report summarizes a brief study made to update information on methods (other than adsorption) for removing or detoxifying PCBs present in industrial wastewater. Information was obtained from Westgate Research and Houston Research on UV-catalyzed ozonation, from Envirogenics Systems Company on catalyzed reduction, and from Environment Canada and others on biodegradation.

In the area of UV-ozonation, both Westgate Research and Houston Research have run tests in which the level of PCBs has been reduced almost to the detection limit of 0.1 ppb. Both companies have stated that they can provide an operational operating costs for a 640 gpm system at $1,750,000 and $120,800/yr., respectively. The decomposition products of UV-ozonation of PCBs are not known at this time. The catalyzed reductive declorination process being developed by Envirogenics has been tested on PCBs. A 75 ppb concentration of the PCB isomer 4,4;-dichlorobiphenyl was reduced to about 1.0 ppb. The Envirogenics process is currently being used at the Velsical Chemical Corporation plant in Memphis where it was put into service in mid-May. It is expected that a contamination level of 1000-15000 ppm of heptachlor and 500-700 ppm of endrin will be reduced to less than 1 ppb of total contaminants. Envirogenics is expecting a grant to set up a plant-scale system to handle PCBs at one of the GE plants. Decomposition products of this process are being investigated.

The work being conducted on biodegradation by Environment Canada has produced a bacterial strain which subsists solely on PCBs. However, this process is not yet ready for commercial scale demonstration because the lowest PCB concentration reached (as of August, 1976) is 19 ppb.

# PCB LEVELS IN NON-CONTACT COOLING WATERS AND OTHER EFFLUENTS FROM CAPACITOR AND TRANSFORMER PRODUCTION FACILITIES

Supplement to Final Report, Task II
January 19, 1977

This work provides a tabulation and analysis of the current status of non-contact cooling water waste streams from the capacitor and transformer production facilities which use PCBs.

Data on PCB levels in 1974-75 and 1976 samples from cooling water effluents from PCB capacitor and transformer manufacturers were obtained for ten streams at six different facilities. All but one of the 1976 levels were below 10 ppb total PCBs, and five were at 2 ppb or lower. These levels are compared to combined plant effluents and rainfall runoff samples at four plants. The highest and most variable PCB levels occurred in runoff samples, and the lowest and least variable occurred in the cooling water effluents. In general, one to two ppb appears to be a typical PCBs level for non-contact cooling water in this industry for plants which practice good plant housekeeping and segregate their cooling water.

# REFINEMENT OF ALTERNATIVE TECHNOLOGIES AND ESTIMATED COSTS FOR REDUCTION OF PCBs IN INDUSTRIAL WASTEWATER FROM THE CAPACITOR AND TRANSFORMER MANUFACTURING CATEGORIES

Supplement to Final Report, Task II
December 16, 1976

This report augments and refines the available information on technology and estimated costs for abatement of PCB discharges from the capacitor and transformer manufacturers who use PCBs in their products. It includes:

1) A description of modifications being performed at two GE plants to reduce PCB effluents;
2) An updated cost estimate for UV-ozonation;
3) A cost estimate for the use of bentonite-lined equalization basins;
4) A general review of the current industry trends towards abatement of PCB discharges.

As of September, 1976, GE had reduced PCB discharges from 8 to 9 pounds per day to one pound per day at their Fort Edward and Hudson Falls manufacturing plants. This was accomplished by:

1) Segregating wastewater;
2) Preventing spills and leaks from contaminating clean water;
3) Decreasing wastewater volume;
4) Eliminating batch dumping;
5) Treating sanitary wastewater at Fort Edward.

Additional projects intended to reduce PCB discharge to less than 1 gram per day were underway and were scheduled for implementation by April or May, 1977.

These include:

1) Recirculating non-contact cooling water;
2) Consolidating discharges and impoundment basins;
3) Treating impounded water at Fort Edward.

The cost of constructing and operating an equalization basin based on the use of a bentonite clay lining was calculated and compared with figures which had been previously derived for a concrete lined basin. It was determined that the annual operating cost for a bentonite lined basin was approximately half that for a concrete basin the same size. In actual practice, however, the bentonite lined pond would be much larger than a concrete lined basin in order to reduce the frequency of pond dredging and cleaning. Thus, the costs for the two alternatives will be more nearly equal.

Westgate Research Corporation's continuing UV-ozonation development program has produced some system simplifications which made it necessary to re-estimate the cost of removing PCBs in a UV-ozonation treatment plant. The new treatment costs ranged from $16.00/1000 gal. for a 20 gpm plant to $1.50/1000 gal. for a 1,700 gpm plant. Typical costs for PCB removal using activated carbon range from $4.47/1000 gal. for 20 gpm capacity to $1.18/1000 gal. for 1,700 gpm.

An examination of current industry trends towards abatement and disposal of PCBs revealed several things. Calgon is furnishing GE with carbon adsorption technology and generally agreed with the technical conclusions and cost estimates determined by Versar. There are at least three PCB users which have no discharge of process water or non-contact cooling water to waterways or POTWs. Segregation of cooling water streams appears to be well in hand or underway in five plants. Three potential suppliers of incinerators for waste PCB-containing liquids indicated that they could supply incinerators within 6 to 18 months of receiving an order.

# COSTS ASSOCIATED WITH INSTALLING PRODUCTION EQUIPMENT FOR USE OF NON-PCB DIELECTRIC FLUIDS IN TRANSFORMER AND CAPACITOR MANUFACTURE

Supplement to Final Report, Task II January 19, 1977

This report summarizes the costs associated with the expected changeover from polychlorinated biphenyls (PCBs) and PCB-containing askarels to substitute (non-PCB) dielectric fluids in the manufacture of transformers and capacitors.

The approach taken was to contact industry representatives at the various meetings of industry committees dealing with disposal of obsolete PCB-contaminated equipment and waste oils. In addition, discussions were held with other industry personnel from whom information on similar matters had been obtained in the past.

The results indicated that no significant process changes would be required of any producer to convert to a PCB substitute. However, minor to extensive retooling will be required for most capacitor producers that produce their own containers and/or utilize their product capacitors in assemblies (ballast assemblies, for example). Design, testing, and other activities required by the product changes will also result in costs associated with the changeover but not with process changes. In addition, clean-up and disposal costs will be borne by all firms.

MICROECONOMIC IMPACTS OF THE PROPOSED MARKING AND DISPOSAL REGULATIONS FOR PCBs

FINAL TASK REPORT

April 1977

EPA 560/6-77-013

NTIS PB 267-833/3WP

This study evaluates the economic impact of the draft regulations for the marking and disposal of PCBs. The report includes estimates of the quantities of PCBs and equipment containing PCBs that will be affected, present and future required availability of PCBs, PCB disposal facilities, secondary costs (including storage), recordkeeping, transportation, and the cost of the actual marking. The economic analysis includes estimates of additional costs by year and economic sector, effects on price, investment requirements, and employment. Finally, the effects of compliance on energy requirements and on the availability of strategic materials are estimated.

The basic disposal requirement for all PCBs is controlled use and storage followed by high temperature incineration. The proposed regulations are very specific on what is to be done and how it is to be done. Consideration of the present lack of incineration facilities and the high costs which would be incurred by requiring removal and special handling of fluorescent light ballasts and small capacitors have resulted in the following exemptions from the basic requirements of incineration:

1) Until July 1, 1979, non-liquid PCB mixtures, PCB capacitors, and PCB fluorescent light ballasts may be disposed of in chemical waste landfills.
2) PCB containers may be decontaminated by triple rinsing.
3) PCB transformer may be rinsed and disposed of in chemical waste landfills.
4) Small PCB capacitors in electrical equipment do not have to be removed before disposal of the equipment.
5) Small capacitors and fluorescent light ballasts used in private homes may be disposed of as municipal solid waste.
6) Material or equipment containing less than 500 ppm of PCBs will not require special handling or disposal.

Most storage areas required by the regulations will be established by office and commercial buildings, electrical repair shops, and small industrial buildings for the storage of small capacitors and fluorescent light ballasts removed during normal maintenance. Cost of establishing a small storage area is estimated at $145 with an annual operating cost of $95/year. It is suggested that these costs may be reduced by using unused space and establishing the area during a time of slack labor demand. A larger area, such as required by utilities and transformer repair shops is estimated to cost $1,000-$5,000 to establish and $2,125 to operate annually.

The draft regulations require that chemical waste landfills used for the disposal of PCBs be approved by the EPA Administrator for that purpose. At present there are sixteen chemical waste landfills in the U.S., but none have been approved for PCB disposal. Average cost for disposing of materials in these landfills, including freight and state fees, is estimated at $3.00 per cubic foot of material.

There are currently nine commercial incinerators with the capacity to destroy liquid PCB waste. In addition, three of these facilities have the capacity to destroy PCBs contained in solid wastes. Charges at these facilities are 7-14¢/lb. for liquid waste and $40/drum for solid waste. Estimated operating cost of a unit capable of shredding and disposing of capacitors is 52¢/lb. It may also be possible to dispose of PCB liquids in cement kilns and power boilers. Shipping charges for liquid PCB wastes in 55 gallon drums range from $1.14 to $6.24 per hundred pounds depending upon the number of drums and the shipping distance. In addition, there may be a charge of $2.85 per platform handling for each drum. There will also be additional recordkeeping charges of $2 to $5 per item.

For estimating the total cost to industry which will be incurred in complying with the draft disposal regulations, three options were identified. Option 1 assumes that all PCB capacitors are removed from equipment before it is scrapped. Option 2 assumes that 2/3 of all small appliance capacitors, HID capacitors, and fluorescent light ballast capacitors are not removed from the equipment but are disposed of as municipal solid waste while the remaining 1/3 are incinerated. Option 3 allows the disposal of fluorescent light ballasts in chemical waste landfills.

Associated with each of these regulatory options are aggregate, industry-wide costs for decontamination, storage, landfill and incineration costs, transportation costs, and recordkeeping costs. The maximum expected cost for decontamination of askarel filled transformers is $365,000 per year. The cost for storing PCBs prior to disposal is estimated to be $8.2 million the first year (including cost for setting up storage areas) and $4.2 million per year in subsequent years. The maximum expected cost for disposal in chemical landfills is expected to be $5.5 million. The estimated incineration costs range from $134 million per year for Option 1 to $39 million per year for Option 3. Estimated transportation costs for incinerating PCBs vary from $7.4 million to $13.2 million per year, depending on how many incinerators are assumed with the various disposal options. Recordkeeping costs are estimated to be $8 million initially plus $4.0 million per year thereafter.

In addition to the economic impacts which will result from the disposal regulations, there will also be substantial costs incurred due to the marking regulations. Manufacturers will be faced with major retooling costs, on the order of $25,000 each, in order to comply with the proposed regulations. The majority of the marking cost, however, will be borne by the present users of PCB electrical equipment who need to mark existing equipment. The total cost is estimated to be $33.2 million.

The aggregate effects which the proposed marking and disposal regulations will have on the electrical pricing, energy consumption, and strategic materials are slight. The price of electricity will increase by an average of 0.06%. The upper bound estimate for increased energy consumption is 17,700 Bbl/day. Reclamation of copper windings from transformers may be inhibited but the total amount affected would be less than 1% of the total copper reclaimed every year in the U.S. and is an insignificant portion of the copper consumed each year.

# POTENTIAL IMPACTS OF THE BANS ON PCB MANUFACTURING, PROCESSING, AND USE
Special Report, PCB Activity Analysis Papers

July 11, 1977

This report describes the current uses of PCBs in the United States and draws particular attention to those uses which present environmental hazards or problems of a regulatory or economic nature.

At the present time the only uses of PCBs in the United States are in capacitors, transformers, and the maintenance of a number of mining machines formerly manufactured by Joy Manufacturing, Inc. Capacitor and transformer manufacturers and transformer maintenance shops currently receive their PCBs from Monsanto, the sole U.S. producer of PCBs. Monsanto intends to stop manufacturing PCBs by August 1977, and will cease shipment from inventory as of October 1977, even though the Toxic Substances Control Act permits the manufacture of PCBs for use in a totally enclosed manner through January 1979. Small custom chemical companies may be attracted to this market, requiring definition of allowable manufacturing processes and/or air and water emission regulations. Another possible source of PCB "manufacture" which may arise is the reclamation of used askarels from transformers. This may create some regulatory difficulties.

It appears that either presently or in the near future, GE and Westinghouse will be the only companies who will service PCB transformers. With the sole domestic producer of PCBs about to cease production, GE and Westinghouse will be forced to decide whether to import PCBs before January 1, 1977, in order to meet an anticipated upward trend in PCB use by the transformer service industry. GE has indicated that in no event will they stockpile more than a 1 or 2 year supply.

In any event, the transformer repair industry will remain a potential source of PCB emissions for the immediate future. PCB air emissions from the repair shops may need to be monitored and regulated. The majority of documented PCB releases attributable to the transformer repair industry have occurred while transporting filled transformers by truck. Draining of transformers before they are shipped would alleviate this problem.

Retrofilling of all PCB transformers with silicone based oil is possible but is not justified on either economic or environmental grounds. The cost would be $45,000-$50,000 each for the largest units, and the increased risk of spills makes this environmentally unattractive. Generally, when a transformer is retrofilled, some of the PCBs remain trapped in the windings. However, it may be possible to remove nearly all the remaining PCBs by periodically filtering the new transformer fluid through activated carbon until the PCBs are reduced to an acceptable level.

The users of PCB equipment may be categorized as utility, commercial-industrial, and residential. It appears unlikely that PCBs used in residences (low voltage capacitors) present any great danger because only small amounts of PCBs are present in any residence and there is little chance that one of these capacitors will rupture upon failure. There is a much greater danger from utilities and commercial-industrial users. Spills or losses are known to occur from damaged equipment and through improper handling of PCB liquids. It is estimated that 78,295 pounds of PCBs will be released into the environment each year from utility transformers and capacitors.

It may be possible for PCBs to enter the environment as a contaminant in another chemical or as a by-product of some chemical process. PCB has been reported as a low-level contaminant in some cases where water containing biphenyl is chlorinated. PCBs already free in the environment may become more of a hazard if contaminated sewage sludge is used as a soil conditioner.

Unless carefully worded, regulations to enforce the ban on "distribution in commerce" could have adverse effects on inventories, equipment resale, and maintenance. Strict enforcement could result in the scrapping of large inventories of capacitors without any decrease in the potential for environmental damage. Another question to be considered is that raised by the disposal of PCB wastes in a landfill. That is, when the title to the material passes from the original owner to the landfill operator, does this constitute "distribution in commerce"?

MICROECONOMIC IMPACTS OF THE DRAFT "PCB BAN REGULATIONS"

(Draft Report) March 8, 1978

This report analyzed the economic impacts of an early draft of the proposed PCB ban regulations. The draft report was used by EPA in preparing the final proposed regulations. The material in this report was superseded by the report of the same title published in May, 1978, except that this draft report included two appendices that did not appear in the published version.

Appendix C of the draft report, "Characterization of U.S. Waste Oil Industry," described in detail the uses of waste oil and characterized the structure of the waste oil collecting and re-refining industry.

Appendix D of the draft report, "Supply and Demand Effects of PCB Ban," presented a formal microeconomic analysis of the supply, demand, and price effects of the increased demand expected for substitutes for PCBs. The purpose of this exposition was to correct an error in a similar analysis previously published by Ashford and Murry of MIT(1).

(1) Ashford, Nicholas A., Murry, Albert E. (1976) The Impact of Governmental Restrictions on the Production and Use of Chemicals: A Case Study on Polychlorinated Biphenyls (Report No. CPA-76-3/b). Cambridge, MA: Center for Policy Alternatives, Massachusetts Institute of Technology, April 30, 1976.

"MICROECONOMIC IMPACTS OF THE PROPOSED "PCB BAN REGULATIONS"

MAY 1978

EPA 560/6-77-035

NTIS PB 281 881/3WP

The purpose of this study was to evaluate the economic impacts of the proposed "PCB Ban Regulations." These regulations were prepared by the Office of Toxic Substances of the U.S. Environmental Protection Agency with the technical support of the Interagency PCB Work Group. These regulations implement the bans on various PCB activities which were established by Congress in Section 6(e) of the Toxic Substances Control Act - Public Law 94-469.

The economic costs reported are those directly and indirectly attributable to those changes in future PCB activities which would be caused by implementation of the proposed regulations. From the wording of Section 6(e), it is clear that the intent of Congress was to ban the manufacture of PCBs after December 31, 1978, and to ban the distribution of polychlorinated biphenyls (PCBs) after June 30, 1979. Therefore, the long-term costs of using substitutes for PCBs will be a consequence of this legislated ban on the manufacture of PCBs and not a consequence of discretionary regulatory actions taken by the Environmental Protection Agency.

This analysis of the proposed regulations considered both the direct costs of complying with the requirements and the indirect effects of these requirements on price levels, capital needs, employment, energy consumption, and the availability of strategic materials. The calculated economic impacts were the incremental impacts of the proposed regulations on a base of 1976 practices as modified by the previously promulgated PCB effluent standards and the marking and disposal regulations. The costs of these other PCB regulations were considered during their development and are not considered to be a result of these proposed ban regulations.

The expected transitional and long term costs resulting from the proposed regulations are summarized in the following tables. The report also estimated employment effects and other economic consequences.

Table 1

Transitional Cost Impacts of Proposed PCB Ban Regulation

| Item (Chapter) | $ Million Per Year 1979 | $ Million Per Year Succeeding Years | $ Million Total | Estimated Reliability of Total |
|---|---|---|---|---|
| PCB Transformers: | | | | |
| Manufacturer clean up costs (16) | $ .1 | 0 | $ .1 | -50% +500% |
| Ban on Rebuilding (4) | | | | |
| Foregone Savings | 14.3 | 3.4% less per year | 420 | ±50% |
| Lost Service Time | 2.4 | 3.4% less per year | 75 | ±50% |
| Transformer Service (5) | | | | |
| Lost Wages | 1 | 0 | 1 | ±100% |
| Spill Prevention Plan | 1 | 0 | 1 | ±100% |
| Locomotive Transformers (6) | | | | |
| Retrofill Program | 7 | 0 | 7 | ±20% |
| Processing Program | 0 | 2.7 (2 years) | 5.4 | ±20% |
| Final Analysis for PCBs | 0 | .1 (1983) | .1 | ±20% |
| Reporting | .005 | 0 | .005 | ±100% |
| Spill Prevention Plan | .02 | 0 | .02 | ±50% |
| PCB Capacitors | | | | |
| Equipment Redesign (15) | * | | | |
| Inventory Obsolescence (3) | 1 | 0 | 1 | ±100% |
| Oil Filled Transformers (7) | | | | |
| PCB Analysis and Disposal | 24 | 3.4% less per year | 700 | ±30% |
| Mining Machines (8) | | | | |
| Rebuild Loaders | Complete by Dec. 31, 1981 | | 2 | ±20% |
| Scrap Continuous Miners | Complete by Dec. 31, 1981 | | .6 | ±50% |
| Reporting Costs | .02 | 0 | .02 | ±100% |
| Spill Prevention Plans | .04 | 0 | .04 | ±50% |

*Data not available to support estimate; probably small cost impact.

Table 1

Transitional Cost Impacts of Proposed PCB Ban Regulation (Continued)

| Item (Chapter) | $ Million Per Year: 1979 | Succeeding Years | $ Million Total | Estimated Reliability of Total |
|---|---|---|---|---|
| Electromagnets (9) | | | | |
| Replacement Cost | $ 3.5 | 0 | $ 3.5 | ±20% |
| Increased Labor Costs | .5 | 0 | .5 | -100% +900% |
| Hydraulic Systems (10) | | | | |
| Die Casting Machines | | | | |
| Analysis and Sampling | .8 | 0 | .8 | ±50% |
| Reporting | .2 | 0 | .2 | ±50% |
| Spill Prevention Plans | .5 | 0 | .5 | ±40% |
| Decontamination | 7.3 | 7.3 (1980) | 14.6 | -30% +200% |
| Other Hydraulic Systems | | | | |
| Decontamination | 3.6 | 0 | 3.6 | -30% +100% |
| Production Interruptions | ** | 0 | ** | ** |
| Heat Transfer Systems (11) | ** | 0 | ** | ** |
| Compressors (12) | .2 | 0 | .2 | -50% +100% |
| Reclaimed Oil (13) | | | | |
| Increased Cost of Synthetic Road Oil Material | 100 | 100 (years 2-5)**** | 500 | -80% +10% |
| Increased Cost of Road Oil | | 6.4 (years 6-15) | 64*** | -80% +200% |
| Lost Production of Reclaimed Hydraulic Fluid | .4 | .4 (1980) | .8 | ±20% |
| Phthalocyanine Pigments (14) | | | | |
| Process Changes | .5 | 0 | .5 | -50% +200% |
| | $168.3 million | | $1,802 million | -60% +40% |

**Data not available to support estimate, potentially large cost impact.
***Costs to continue indefinitely until waste industrial oil no longer contains measurable amounts of PCBs.
****Upper bound estimate. Decreased demand may result in significantly reduced impacts.

Table 2

Long Term Cost Impacts of Proposed PCB Ban Regulations

| | |
|---|---|
| **Transformers: (Chapter 16)** | |
| Increased cost of non-PCB transformers | $0 to 10 million/year |
| Increased fire losses | Data not available |
| **Capacitors: (Chapter 15):** | |
| Increased cost of non-PCB power factor capacitors | $5.5 to 10.9 million/year |
| Increased cost of non-PCB capacitors | $7.8 to 10.3 million/year (± 50%) |
| Increased fire losses | Data not available |
| Decreased service life | Data not available |
| **Dairylide Yellow Pigment (Chapter 14)** | |
| Increased cost of substitute pigments | $10 to 25 million/year |
| TOTAL | $23 to 56 million/year |

Present value of long term cost impacts assuming 10% discount rate = $230 to 560 million

PCB MANUFACTURING, PROCESSING, DISTRIBUTION IN COMMERCE, AND USE BAN REGULATION: ECONOMIC IMPACT ANALYSIS

FINAL REPORT

MARCH 1979

EPA 230-03/79-001

NTIS No. forthcoming

This report is a revision of the report "Microeconomic Impacts of the proposed PCB Ban Regulations." The report summarizes the economic impacts of the promulgated ban regulations and incorporates the information made available during the rulemaking hearings on the proposed regulation. The total economic costs and estimated pounds of PCBs diverted from the environment by the regulation are summarized the following Table.

## Economic Costs of the PCB Ban Regulation

| Chapter Number | Item | Total Cost $ Million | Pounds PCBs Diverted from the Environment | Cost per Pound of PCBs |
|---|---|---|---|---|
| 3 | Scrap Spare PCB Capacitors | 1 | 500 | $ 2,000 |
| 3 | Remove PCB Capacitors from Equipment in Inventory | 1,000 | 5,360 | $187,000 |
| | | These costs will be significantly reduced or eliminated if EPA grants exemptions from the "distribution in commerce" ban. | | |
| 4 | Ban Rebuilding Askarel Transformers | 397 to 771 (30 yrs) | 47,000 to 925,000 | $429 to $16,400 |
| 5 | Retrofill Railroad Transformers to 6% | 6.7 | **(3.76 million lb) total | **(>$1.75) |
| 5 | Retrofill Railroad Transformers from 6% to .1% | 5.15 | **(80,240 lb. total) | **(>$68) |
| 6 | Require Incineration of Transformer Oil | 96 to 510 (30 yrs) | 200,000 | $480 to $2,550 |
| 7 | Special Storage Areas at Transformer Service Stops | * | * | * |
| 8 | Retrofill/Ban PCB Miner Motors | 2.6 to 4.3 | ? (27,500 lb total) | ? (>$94 to $155) |
| 9 | Ban Rebuilding Electro-magnets | .96 | 200 to 2,000 | $480 to $4,800 |

*Information not available in record to make estimate.

**Figure represents total amount of PCBs in this use. Information not available in record to make an estimate of amount diverted from the environment.

ECONOMIC COSTS OF THE PCB BAN REGULATION (Continued)

| Chapter Number | Item | Total Cost $ Million | Pounds PCBs Diverted from the Environment | Cost per Pound of PCBS |
|---|---|---|---|---|
| 10 | Decontaminate Hydraulic Systems | 21.4 to 25 | 470 to 2,390 | $6,000 to $53,000 |
| 11 | Decontaminate Heat Transfer Systems | 12.8 to 17.2 | 1,872 to 2,496 | $6,870 |
| 12 | Decontaminate Compressors | .2 | * | * |
| 13 | Ban Use of Waste Oil on Roads | 0 to 31.7/year | 8,073/year | $0 to $3,925 |
| 14 | Phthalocyanine Blue Pigments | .425/year | 544/year | $781 |
| 14 | Diarylide Yellow Pigments | .478/year | 441/year | $1,084 |
| 15 | Spill Materials (50-500ppm)-to Chemical Waste Landfill | * | * | $182 |
| 16 | Ban New Large PCB Capacitors | 5.5 to 11/year | 14,200 | $387 to $775 |
| 16 | Ban New Small PCB Capacitors | 6.6 to 18.9/year | 6,930/year | $950 to $2,730 |
| 17 | Ban New PCB Transformers | 0 to 10/year | 12,000/year | $0 to $833 |

*Information not available in the record to make estimate.

| BIBLIOGRAPHIC DATA SHEET | 1. Report No. EPA 560/6-79-004 | 2. | 3. Recipient's Accession No. |
|---|---|---|---|
| 4. Title and Subtitle<br>Polychlorinated Biphenyls 1929-1979: Final Report | | | 5. Report Date<br>May 16, 1979<br>6. |
| 7. Author(s)<br>Robert A. Westin | | | 8. Performing Organization Rept. No. 474.5F |
| 9. Performing Organization Name and Address<br>VERSAR, Inc.<br>6621 Electronic Drive<br>Springfield, Virginia 22151 | | | 10. Project/Task/Work Unit No.<br>11. Contract/Grant No.<br>68-01-3259 |
| 12. Sponsoring Organization Name and Address<br>Office of Toxic Substances<br>U. S. Environmental Protection Agency<br>Washington, D. C. 20460 | | | 13. Type of Report & Period Covered<br>Final Report<br>14. |

15. Supplementary Notes

EPA Program Manager: Mr. Thomas E. Kopp

16. Abstracts

The primary emphasis of this report is a summary of the work that Versar performed in support of the EPA's regulatory activities involving polychlorinated biphenyls over the past four years. The report includes summaries of 24 reports on PCBs that Versar submitted to EPA during this period. Also included are a summary of the uses of PCBs from 1929 through 1979, a review of much of the early literature on the uses and toxicity of PCBs, and a discussion of the various regulatory activities that limited human exposure to PCBs and eventually banned their manufacture, processing, and use.

17. Key Words and Document Analysis. 17a. Descriptors

Polychlorinated biphenyls
PCBs
Regulations
Water Pollution Abatement
Economic Analysis
Toxic Substances Control Act
Toxicity
Environmental Transport
Effluents

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

| 18. Availability Statement | 19. Security Class (This Report) UNCLASSIFIED | 21. No. of Pages 90 |
|---|---|---|
| | 20. Security Class (This Page) UNCLASSIFIED | 22. Price |