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EPA

Microeconomic Impacts of the Proposed "PCB Ban Regulation"

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MICROECONOMIC IMPACTS OF THE PROPOSED 'PCB BAN REGULATIONS'

FINAL TASK REPORT

Submitted to:

U.S. Environmental Protection Agency
Office of Planning and Management
Washington, D.C.

Attention: Mr. Steven B. Malkenson
Project Officer

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PREFACE

This report was prepared by Versar Inc. for the Office of Planning and Management of the U. S. Environmental Protection Agency. The report summarizes Versar's estimates of the probable costs and impacts of complying with the proposed "PCB Ban Regulations." These regulations were prepared by the EPA Office of Toxic Substances and the Interagency PCB Work Group to implement the requirements of Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act (Appendix A).

This economic analysis program was sponsored by the EPA, but the results reported are those of Versar Inc. This report was prepared in partial fulfillment of the requirements of Contract No. 68-01-4771. The report is not a statement of EPA policy. However, this study does meet the requirements of an economic impact analysis of the proposed regulation.

This report was prepared under the supervision of Mr. Robert Westin, Principal Investigator. Major contributors were:

Louis Fourt, Ph.D. (economic methodology, waste oil, railroads)
Robert Westin, P.E. (transformers, dry pigments)
David Berkey (capacitors, mining machines)
Bruce Woodcock (hydraulic systems, turbines)

Special acknowledgements must be given for the close support received from Mr. Steven B. Malkenson, EPA Project Officer, and Mr. Joseph F. Lackey, EPA Regulations Development Group of the Office of Toxic Substances. The factual strengths of this report are due to the close cooperation received from industry, particularly representatives of the transformer and capacitor manufacturers and the electric utilities.

This report is being released and circulated prior to the public hearing on the proposed regulation. It will be considered along with the information received during the hearing in establishing the final regulations. Prior to final promulgation of the regulations, this study shall have standing in any EPA proceeding or court proceeding only to the extent that it represents the views of Versar Inc. It cannot be cited, referenced, or represented in any respect in any such proceeding as a statement of EPA's views regarding the impact of the proposed regulations.

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1.0 INTRODUCTION

1.1 Purpose and Scope

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 (see Appendix A).

The economic costs reported herein 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 Contress 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.

The effect of the authorizations in Section 761.31 of the proposed regulations will, in each case, be to reduce the economic impacts which could have resulted from the immediate application of the bans set forth in the act to PCB equipment and articles. The costs which were estimated as resulting from these authorizations were the incremental costs based on the pre-1977 base, and not the changes from the higher costs which would result in the absence of these authorizations. However, the assumptions behind the analysis of the individually identified impacts are explicitly identified, and the analysis should support the evaluation of alternative regulatory approaches.

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.

1.2 PCBs Usage in the United States

PCBs have been used in the United States since 1929. Major uses of this chemical have included transformer cooling liquids; capacitor dielectric liquids; heat transfer and hydraulic liquids; as a dye carrier in carbonless copy paper; as a plasticizer in paints, adhesives and caulking compounds; and as a filler in investment casting wax. A previous EPA contractor report[1] estimated the usage and distribution of PCBs to be as shown in Table 1.2-1.

(1) Versar Inc. PCBs in the United States: Industrial Use and Environmental Distribution. Springfield, Va.: National Technical Information Service (NTIS PB 252 402/3WP). February 1976.

Table 1.2-1

Estimates of Cumulative PCBs Production, Usage, and Gross Environmental Distribution in the United States Over the Period 1930-1975 in Millions of Pounds

	Commercial Production	Commercial Sales	Industrial Purchases of PCB	PCBs Currently in Service	PCBs Currently in Environment	PCBs Destroyed	Estimated Reliability of Values
U.S. PCB Production	1,400						+ 5% - 20%
Total U.S. PCB Imports	3						± 30%
U.S. PCB Domestic Usage		1,253					+ 5% - 20%
Total U.S. PCB Exports		150					± 20%
PCB by Use Category:							
Petroleum Additives			1				± 50%
Heat Transfer			20				± 10%
Misc. Industrial			27				± 15%
Carbonless Copy Paper			45				± 5%
Hydraulics and Lubricants			80				± 10%
Other Plasticizer Uses			115				± 15%
Capacitors			630	450			± 20%
Transformers			335	300			± 20%
Uses Other than Electrical				8			± 60%
PCB Degraded or Incinerated:							
Environmentally Degraded						30	± 70%
Incinerated						25	± 10%
Landfills and PCBs in Dumps:							
Cap. and Trans. Production Wastes					110		± 20%
Obsolete Ele. Equipment					80		± 40%
Other (paper, plastic, etc.)					100		± 40%
Free PCBs in the Environment (soil, water, air, sediment)					150		± 30%
Total	1,403	1,403	1,253	758	440	55	

1.2.1 Production of PCBs

The major U.S. manufacturer of PCBs has been Monsanto. Since 1972, Monsanto has limited sales of PCBs to manufacturers of transformers and capacitors. Monsanto ceased manufacturing PCBs in mid-1977, and shipped the last remaining inventory by October 31, 1977. A previous EPA sponsored study[1] indicated that about one million pounds of PCBs were also manufactured by a small chemical company from 1972 through 1974 for use as a heat transfer liquid.

PCBs may also be made as unintentional by-products of other chemical processes. For instance, the manufacture of the dry pigment phthalocyanine blue by reaction of precursors dissolved in trichlorobenzene may result in the formation of PCBs from reactions involving the trichlorobenzene. These PCBs may contaminate the pigment at PCB concentrations from parts per million to as much as 0.1 percent. Production of diarylide yellow pigments also results in the formation of dichlorobiphenyl due to a side reaction involving the pigment precursor dichlorobenzidine. This results in PCB concentrations in the yellow pigment of up to several hundred parts per million. Chlorination of water which contains appreciable concentrations of biphenyl (which is used as a dye carrier in dying polyester fibers and which is a common pollutant of water discharged from dying plants) can result in the unintentional formation of PCBs to a concentration of several parts per million. No natural (non-industrial) sources of PCBs have been identified.

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(1) Versar Inc. Usage of PCBs in Open and Semi-Closed Systems and the Resulting Losses of PCBs to the Environment. EPA 560/6-77-009 (unpublished Draft Report) September 1, 1976.

1.2.2 Imports of PCBs

PCBs have been imported for use in investment casting wax, for maintenance of certain mining machinery, and as the coolant in electrical transformers.[1]

Decachlorobiphenyl was imported from Italy for several years for use as a filler in investment casting wax; this use was ended in mid-1976.[1] Several manufacturers of investment casting wax are presently using imported polychlorinated terphenyls (PCTs) in their products. The U. S. distributor of PCTs has given assurances that PCBs are present only at concentrations below 0.005 percent,[2] but no data are available on the actual concentration of PCBs found in these PCTs.

Over 700,000 pounds of PCBs have been imported since 1972 to maintain certain mining machines which use PCBs as a motor coolant.[3] No additional PCBs will be imported for this use as existing U.S. inventories are reported to be sufficient to meet maintenance requirements for the remaining service life of the machines.

PCBs have also been imported as components of transformers and capacitors. This source of PCBs does not seem to be significant at present.

1.2.3 Hydraulic System, Heat Transfer System, and Compressor Use

PCBs have not been commercially available for open system uses since 1974. Leakage of PCB hydraulic fluid was replaced by PCBs taken from remaining maintenance supplies and, after these were exhausted, by

(1) Versar Inc. Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs. EPA 560/6-77-007, July, 1977.

(2) Personal communication, Mr. L. M. Argueso (M. Argueso and Co., Mamaroneck, N.Y.), August 30, 1977.

(3) Versar Inc. Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs. EPA 560/6-77-007, July, 1977, pp 9, 10.

compatible non-PCB fluids. As a result, the PCBs in service in these machines in the early 1970's have been diluted. Information obtained during the course of this study through a phone survey of users of these systems indicates that the fluid presently in the machines may contain from 60 ppm to 50 percent PCBs, depending on the amount of leakage and replacement over the past five years.

When Monsanto discontinued the manufacture of PCB based heat transfer liquid in 1972, they recommended that existing systems be drained and flushed and the liquid replaced with a non-PCB liquid. A number of systems were maintained through 1974 with PCBs manufactured by a small chemical company, but no PCB heat transfer fluids were manufactured or imported after 1974, and it is believed that all systems have been drained and converted to non-PCB fluid. The effectiveness of the initial flushing procedure is known for only one system which was flushed in 1972 and presently is using a fluid which is contaminated by two percent PCBs.

PCBs were used as a working fluid in a number of turbine compressors on natural gas pipelines in the early 1970's. Although the PCB oil has since been drained and the turbines flushed and refilled, residual PCBs are present to a concentration of up to several thousand parts per million in the oil.

Another use of PCBs was as a minor additive to certain automobile transmission fluids to cause controlled swelling of rubber seals. Although this use stopped in the early 1970's, waste lubricating oils have been reported to contain PCBs in concentrations of parts per million. Transmission fluid from older automobiles may be the source of this unintentional contamination of waste oil, but no information is available on the extent of PCBs in transmission fluids.

Contaminated oils have not been segregated from the flow of oil collected for reclamation. As a result, much of the oil presently handled by the waste oil collectors, processors, and re-refiners appears to be contaminated with low levels of PCBs.

1.2.4 Transformer Manufacturing and Maintenance

Most large electrical transformers are designed to operate with the current-carrying coils immersed in a dielectric liquid. This liquid provides electrical insulation between the windings by filling in any pinholes in the enamel or paper insulation. The liquid also performs as a heat transfer media by absorbing heat from the coils and conducting it to the outer shell or heat transfer surfaces by natural or forced convection. Most liquid-filled transformers are cooled with mineral oil. This oil can present a significant fire hazard in the event of a short circuit within the transformer. Therefore, oil-filled transformers are not allowed to be used in hazardous locations such as buildings except when installed in a fire resistant concrete vault.

In the past, most transformers used in hazardous locations have been filled with non-flammable coolant liquids containing PCBs as a major component. These PCB transformer liquids are known by the generic term "askarel" and have been in common use since the 1930's in hazardous transformer applications. Although the PCB filled transformers have cost 20 percent more than oil filled units, they have found wide use as they are non-flammable and more reliable than oil-filled transformers.

The manufacturers of PCB transformers discontinued manufacturing PCB transformers by the end of 1977. There are presently in use approximately 140,000 PCB transformers which contain an average of 300 gallons of liquid (2,150 lb PCB). The average service life of these askarel transformers is about 40 years, if certain routine maintenance is performed.

The electrical properties of askarel are significantly degraded by the presence of moisture. Thermal cycling of the transformer during normal use can draw air into the transformer through minor leaks in bushings, and the askarel will absorb moisture from this air. It is routine practice to check the electrical properties of the askarel periodically at intervals from 1 to 5 years depending on ambient air moisture. If moisture is detected, the askarel is drained and filtered (to remove the moisture), and the bushings are repaired. This maintenance, usually performed in the field, is necessary to assure continued safe operation of the transformer as severe degradation of the askarel can cause major arcing within the transformer.

Similar maintenance has been routinely performed on the several million oil-filled transformers. The oil in many of these units may be contamined with PCBs to a concentration of several hundred parts per million due to past use of the same equipment to service both oil-filled and askarel transformers. It is also possible that PCB contamination of the oil may have occurred in the manufacturing process where plants made both oil-filled and askarel transformers. Disposal of transformer oil has been through commercial waste oil haulers, which has apparently further increased levels of PCB contamination of reprocessed and reclaimed oils.

1.2.5 Electromagnets

Several hundred electromagnets have been manufactured with PCB oil as a coolant. These magnets are used as magnetic separators over coal conveyor belts. The magnets are similar in construction to transformers. There is no present use of PCBs by this industry for either manufacturing or maintenance.

1.2.6 Capacitors

PCBs have been used as the liquid dielectric in almost all AC (alternating current) capacitors made in the United States since the mid-1930's. PCBs are unexcelled in their properties of chemical stability, fire resistance, and high dielectric strength. Although no other dielectric liquids equivalent in performance to PCBs have been developed, other liquids are being used successfully in capacitors which perform the same function as PCB capacitors. All of the manufacturers of large power factor capacitors have switched to non-PCB substitutes. Most of the manufacturers of small capacitors have either stopped using PCBs or announced their intention to switch to other liquids early in 1978.

1.3 PCB Restrictions in the Toxic Substances Control Act

Prior to the enactment of the Toxic Substances Control Act, the only authority of the EPA with respect to PCBs dealt with discharge of contaminated water from industrial point sources. On February 2, 1977, the EPA promulgated regulations under Section 307(a) of the Federal Water Pollution Control Act which banned the direct discharge of water contaminated with PCBs by electrical transformer and capacitor manufacturers after February 1, 1978.(1)

The enactment of the Toxic Substances Control Act (in October, 1976) placed additional requirements on the use of PCBs and required that certain actions be taken by the EPA. Section 6(e)(1) of the Act required that the EPA promulgate marking and disposal regulations for PCBs. These regulations were promulgated on February 17, 1978.(2) The regulations require that special warning labels be applied to PCB equipment, containers,

(1) EPA "Final Decision" Federal Register, Feb. 2, 1977, pp. 6531-6555.

(2) EPA, "Polychlorinated Biphenyls (PCBS): Disposal and Marking," Federal Register, February 17, 1978, pp. 7149-7164.

and storage areas. The regulations also require that disposal of PCB liquids, materials and equipment by by approved methods (generally high temperature incineration or chemical waste landfill) and establish approval criteria for the disposal facilities.

The Toxic Substances Control Act also established cutoff dates for certain PCB activities as follows:

January 1, 1978:	All manufacturing processing, distribution and use must be in a totally enclosed manner.
January 1, 1979:	No further manufacturing or importing of PCBs allowed.
July 1, 1979:	No further processing or distribution in commerce of PCBs allowed.

The proposed PCB Ban Regulations implement these requirements of the Act and also authorize the continuation of specific activities where the EPA has determined that such activities will not present an unreasonable risk of injury to health or the environment.

1.4 Summary of Proposed Ban Regulations

The continued manufacturing, processing, distribution in commerce, and use of PCBs has been regulated by Congress. Section 6(e) of the Toxic Substances Control Act (Public L. 94-469, 90 STAT 2025), established various restrictions on PCB activities and the dates on which these restrictions become effective. EPA is required by Section 6(e) to establish by rule several technical findings regarding PCB activities. These findings must establish:

(1) The level of exposure of human beings and the environment to PCBs that may be considered insignificant [Section 6(e)(2)(C)]. This level of exposure is the basis for judging whether any activity or use is in "a totally enclosed manner."

(2) Whether certain uses present an unreasonable risk to health or the environment. This criterion is to be used as the basis for authorizations of activities that are not conducted in a totally enclosed manner, and in evaluating petitions for one year exemptions from the mandated bans on the manufacturing, processing, and distribution in commerce of PCBs. [Section 6(e) (3)(B)].

(3) Those activities which, although not conducted in a totally enclosed manner, nevertheless will not present an unreasonable risk of injury to health or the environment. [Section 6(e)(2)(B)].

The proposed "PCB Ban Regulations" state these findings, incorporate the mandatory requirements established by Congress, and would grant authorizations for continuation of certain activities based on the findings. These regulations were prepared by the EPA Office of Toxic Substances in cooperation with the Interagency PCB Work Group. The basis for the proposed regulations is the finding that there is no identifiable level of PCB release to the environment that can be considered insignificant. Therefore, only totally enclosed activities such as continued usage of existing transformers and capacitors will meet the criteria required after December 31, 1977.

The Toxic Substances Control Act grants the EPA authority to permit other PCB activities after the end of 1977 if the activities do not present an unreasonable risk to health or the environment. Acting under this authority, the EPA in the proposed ban regulations would permit the following PCB activities in other than a totally enclosed manner.

(a) Continued minor maintenance of PCB transformers to minimize the economic impacts that would result from premature retirement and lack of replacement units.

(b) Continued use and scheduled phase-out of use of PCB railroad locomotive power transformers.

(c) Continued use and scheduled phase-out of use of PCB-filled motors used on certain mining equipment.

(d) Continued use of certain hydraulic systems contaminated with PCBs if efforts are periodically made to decontaminate the systems.

(e) Use of waste oils contaminated with PCBs below a concentration of 50 ppm, except as a sealant, coating or dust control agent. This could ban the use of oil contaminated with any measurable amount of PCB for oiling roads or as a pesticide carrier.

1.5 Effects of the Proposed Regulations by PCB Use

The economic impacts resulting from the proposed regulations were determined by evaluating the effects of the regulations on each identifiable PCB use. The report of the analysis also addresses each use in a separate chapter, and the format of the report, therefore, does not parallel the format of the regulation. A guide to the discussion of the various sections of the proposed regulations is presented in Table 1.5-1. The various cost and economic impacts are summarized in Chapter 17.

Table 1.5-1

Effect of the Proposed PCB Ban Regulations on Various Uses of PCBs

Chapter of Report Discussing Impacts

Subpart of Proposed PCB Ban Regulation	3. Ban on capacitor distribution in commerce	4. Users of Askarel Transformers	5. Transformer Service Companies	6. Railroad Locomotive Transformers	7. Oil Filled Transformers	8. Mining Machines	9. Electromagnets	10. Hydraulic Systems	11. Heat Transfer Systems	12. Compressors	13. Reclaimed Oil	14. Unintentional Product Contaminants	15. Capacitor Manufacturing	16. Transformer Manufacturing
A2 Definitions														
(q) PCBs	X			X							X	X		
(w) Mixture				X				X	X	X	X	X		
(cc) Dust Control Agent											X			
(dd) Process				X				X	X	X	X	X		
(hh) Totally Encl. Manner		X	X		X	X	X	X	X	X	X	X		
(ii) Waste Oil			X	X							X			
B Disposal														
(c) (1) (B) Transformer, PCB less than 500 ppm					X									
C Marking														
(a) (3) (i) Transformer, PCB less than 500 ppm					X									
D Prohibitions														
761.30 Tot. Encl. Manner	X	X	X	X	X	X	X	X	X	X				
(a) Manuf. & Use Ban except in totally enclosed manner		X	X		X	X	X	X	X	X	X	X	X	X
(b) 1-1-79 Manuf. & Use Ban	X	X	X		X	X		X			X	X	X	X
(c) 7-1-79 Distrib. ban	X	X	X											
761.31 Authorizations														
(a) Transformer Servicing		X	X											
(b) Transformer Distribution in Commerce		X	X											
(c) Railroad Transformers				X										
(d) Mining Machines						X								
(e) Hydraulic Systems								X						
Annex VII - Spill Control Plans			X	X		X		X						

2.0 METHODOLOGY FOR ECONOMIC IMPACT ANALYSIS OF THE PROPOSED "PCB BAN REGULATIONS"

2.1 General Approach

The approach used in developing the economic impact analysis of the proposed "PCB Ban Regulations" is summarized below:

(1) Each industry significantly affected by the draft regulations is considered separately. The analytical methodology used is the same for each industry, and the results are presented in a format permitting aggregation.

(2) Analysis is limited to impacts expected to result from the proposed ban regulations. The impacts are the incremental changes from a base condition assumed to be the industry practices in 1975 as modified by the PCB effluent standards, and the PCB Disposal and Marking regulations.

(3) Increased industry costs due to the use of substitutes for PCBs and the resulting product development costs or the costs of discontinuing certain products are the basis of the calculation of cost impacts. The resulting price and product quality effects are used to calculate expected changes in demand and market shifts among competing products. The impact of these market effects on individual industries is used to calculate employment changes.

(4) Each industry is regarded as a link in an input-output chain or web. Thus, changes in output affect customer industries and, logically, customers' customers. In most cases, the economic analysis is extended only to the first tier customers, and secondary impacts were assumed to be negligible.

(5) The chain effects are also traced backward at least one stage to suppliers; price, quality and delivery effects are considered as determinants of quantity demanded.

(6) At each stage (supplier, directly impacted producer, customer), impacts on the various factors of production were considered. Physical factors of production at each stage include labor, materials, equipment, factory space and land. There may also be impacts on fixed and working capital requirements and capital markets, including rental or leasing arrangements.

(7) Significant externalities are considered in the analysis.

(8) The analysis considers only the costs incurred by the regulations. No estimates are made of the benefits to health or the environment achieved by banning the use of PCBs.

(9) Distinction is made between transitional and long term effects. Transitional effects include the costs of premature obsolescence of production facilities and equipment, retooling, research and development, and temporary unemployment caused by market shifts. Long term effects include increased prices and changes in aggregate market demand.

The economic impacts for each affected industry are tabulated in the following format:

Variable	Transitional Impact	Long Term Impact
price of output		
quantity produced		
labor employed		

Secondary economic effects which are discussed where relevant include wages paid, materials used, product redesign, new investment, space requirements. servicing costs, product reliability, fire safety, and analytical testing costs.

2.2 Definition of Economic Impact

Impact is defined as the changes resulting from the implementation of the regulation. Calculation of the impact requires that the base condition be carefully defined to exclude the effects of the proposed regulation but to include the effects of standard industry practices and other relevant regulations and laws. In the present case, the base period used to define industry practices is assumed to be 1975. Thus, the effects of the voluntary ban on open system uses of PCBs that was taken by Monsanto in 1972 is fully reflected in the base condition, but other actions taken by industry in anticipation of the requirements of the Toxic Substances Control Act do not affect this base condition. The impact analysis then distinguishes the impacts of the proposed ban regulations from the effects of the PCB Effluent Discharge Regulations, the PCB Disposal and Marking Regulations, and the ban provisions of the Act which caused Monsanto to cease PCB production in 1977.

Versar used two major data resources to establish the base condition:

(1) Testimony at the public hearings in Washington (July 15, 1977) and in Chicago (July 19, 1977); and

(2) Interviews with affected parties, conducted mostly by telephone with information contacts established by Versar during previous PCBs study tasks.

3.0 IMPACTS OF BANS ON THE DISTRIBUTION OF PCB CAPACITORS AND EQUIPMENT

The proposed ban regulations would require that PCB capacitors not be installed in newly manufactured products after December 31, 1978, and that new equipment containing PCB capacitors not be distributed in commerce after June 30, 1979. The ban on manufacturing would apply not only to the installation of a capacitor in a piece of electrical apparatus, but also to the installation of any 'PCB Equipment' in a larger assembly. For instance, the December 31 ban would apply to the assembly of a PCB capacitor into a lighting ballast, the assembly of a PCB ballast into a lighting fixture, and to the assembly of a PCB lighting fixture into a subway car. Buildings containing PCB capacitors, however, are specifically defined as not being 'PCB Equipment'. The ban on distribution of newly manufactured goods in commerce would also apply to all of the varieties of 'PCB Equipment'.

3.1 Effect of the Ban Regulations

Most manufacturers of ac capacitors switched to substitutes for the PCB dielectric liquids by early 1978. No PCB capacitors are expected to be manufactured after August, 1978, when Aerovox Corporation expects to exhaust its inventory of PCB liquids. Manufacturers who use PCB capacitors as components of 'PCB Equipment' will generally be able to use up their inventories of PCB capacitors by the end of the year, and little inventory loss is expected.

The greatest impact of this portion of the ban regulations may be on retail inventories of appliances such as air conditioners and television sets. Units manufactured before December 31, 1978 with PCB capacitors may not all be sold to the ultimate user by June 30, 1979 when their further 'distribution in commerce' would be banned. The practical effect of this ban is not expected to be great since such appliances would not be labeled as PCB equipment (since the labeling requirement does not become effective until January 1, 1979), and the appliances would be widely distributed in retailer's inventories. The limited number of PCB items still in inventory could not easily be identified, and the practical difficulty of enforcement would limit the real impact of the regulation. Should any special situations result in large numbers of new PCB appliances in wholesaler's or retailer's inventories on June 30, 1979, the owners of the units could apply to the EPA for a temporary exemption from the provision of the ban regulations similar to that which is discussed in the preamble to the proposed regulation for the continued use of PCB capacitors in the repair of electrical equipment.

3.2 Summary

The only impacts of the proposed bans on 'distribution in commerce' may be the obsolescence of certain retailer inventories of PCB appliances. Options available to such impacted parties include the replacement of PCB capacitors with non-PCB units, or the application to the EPA for an exception to the ban regulation. Total costs are unlikely to exceed a few hundred dollars per affected establishment, and would likely total less than one million dollars. The practical difficulty in enforcing this part of the regulation will probably result in real impacts considerably lower than these estimated amounts.

4.0 IMPACTS ON USERS OF ASKAREL TRANSFORMERS

Versar estimates that there are about 140,000 askarel transformers in use. About 1,000 of these are being used on railroad locomotives and commuter cars; the impact of the draft regulations on these railroad locomotives is discussed in detail in Chapter 6. Of the remaining units, most are pad mounted distribution and power transformers located in buildings and electric generating stations, with a substantial number of askarel precipitator transformers being mounted on stacks. The distribution of ownership of these transformers is summarized in Table 4.0-1. With an estimated average of 2,500 pounds of PCBs in each transformer, the total in-service inventory of PCBs in transformers is approximately 300,000,000 pounds. The transformers are owned and maintained by either the utility or the user, depending on the business arrangements made at the time of each installation.

Table 4.0-1

Estimated Number of PCB Transformers in Service

Category of User	Number of Units	PCB Content-Pounds
Utilities	42,000	105,000,000
Industrial and Commercial	97,000	191,000,000
Railroad	1,000	4,000,000
	140,000	300,000,000

4.1 Requirements of the Proposed Regulations

The proposed ban regulations forbid the major rebuilding of askarel transformers. Therefore, failed askarel transformers would have to be replaced with suitable non-PCB replacement units rather than being rebuilt. Increased costs will be incurred at the time of failure of all 140,000 existing askarel transformers.

4.2 Compliance Costs

Foregone Savings from Rebuilding

If it is assumed that a replacement transformer of a satisfactory high fire point liquid cooled design would cost the same as the historical price for an askarel transformer (see Chapter 16), and that rebuilding would cost 70% of the cost of the new transformer if allowed,[1] then the foregone savings from banning rebuilding of askarel transformers would be 30% of the cost of the units. Based on an average cost of $20,000 per transformer, foregone savings will be $6,000 per askarel transformer.

Total foregone savings will depend on the proportion of askarel transformers which are scrapped because of non-repairable failures or obsolescence rather than because of repairable failures. An active market in used askarel transformers existed in the past, but this market has become much less active over the past year because the provisions of the water pollution control regulations and the OSHA regulations on worker exposure to PCBs have increased the risk of using askarel transformers. No data is available on the proportion of askarel transformers that are removed from service prior to failure, and even if historical data were available it could be misleading because most askarel transformers have not been in service long enough for aging of the insulation to increase the risk of failure of the units. It is likely, based on Versar's estimates rather than on hard data, that one-third to two-thirds of the existing askarel transformers will be retired due to obsolescence prior to failure. The total foregone savings would therefore be $6,000 per unit x 1/3 to 2/3 of the 140,000 units in service, or a total of $280 million to $560 million.

Timing of these foregone savings will depend on the rate at which askarel transformers fail. Present failure rates are low because of the relatively young age of most existing units. A previous EPA sponsored study[2] estimated that approximately 80,000 gallons of PCBs were used in

(1) Based on a consensus of industry estimates obtained by Versar during a telephone survey of transformer manufacturers and rebuilders.

(2) Versar Inc., PCBs in the United States: Industrial Use and Environmental Distribution. Springfield, VA: National Technical Information Service, (NTIS PB 252 402/3WP), February, 1976. p. 114.

the repair of askarel transformers in 1974. Assuming an average transformer capacity of 240 gallons, of PCBs (300 gallons of 'askarel' mixture) this implies that a total of 335 askarel transformers were repaired during that year. This would have to be considered a lower bound estimate of the future impacts of the ban on rebuilding as the rate of failure of askarel transformers is expected to increase as the average age increases. An upper bound estimate might reasonably be based on an average expected remaining service life. If it is assumed, for example, that one-half of the existing askarel transformers will be removed from service over the next twenty years due to failure or obsolescence, an average rate of removal from service of 3.4% of existing units is implied. If the probability of failure or removal were independent of the age of the unit, it would be expected that 3.4% of the 140,000 existing units would be retired in 1979, or a total of 4,760 units removed, of which 1/3 to 2/3 (1,587 to 3,173) would have failed. The range of expected failures would therefore be about 335 to 3,173 transformers per year, resulting in annual costs due to foregone savings of $2 million to $19 million per year during the next few years. At an average failure rate of 4760 units per year and an average rebuilding ratio of 50%, foregone savings would be $14,280,000 in 1979.

Lost Service Time

Transformers can be rebuilt and returned to service in three to four weeks, compared to a delivery time of 12 to 16 weeks for new units. In the case of many small manufacturing compaines, failure of the single transformer which supplies all of the power for the facility can stop all operations until a satisfactory replacement unit is obtained. It is likely that a greater supply of replacement units will become available in response to a growing demand for fast restoration of service. This increased inventory of spare units will result in increased costs to the companies maintaining the units and increased prices to the users who will be willing to pay more to avoid prolonged loss of electric service. There is no information available as to the costs of renting replacement transformers, but assuming a reasonable monthly rental of 2% of the cost of the unit, total costs due to the longer lead times for replacement transformers could increase by the cost of two to three month's rental of an average $20,000 unit or $800 to $1,200 per failed transformer. Based on the assumed number and frequency of askarel transformer failures, total costs due to lost service time would be ($800 x 140,000/3 = $37 million) to ($1,200 x 140,000 x 2/3 = $112 million), and annual costs of ($800 x 335 units = $268,000) to ($120 x 3,173 units = $3,800,000) would be expected, with an average cost of (.5 x 4760 units x $1000 rental per unit = $2,380,000) expected in 1979.

4.3 Economic Impact of Cost Increases

The increased costs to users of askarel transformers will be borne by the owners of the units. Approximately one-half of the units are owned by utilities, and their increased costs are expected to be factored into the rate base and passed along to the users of electricity. The other half of the units are owned by major office and apartment buildings and by shopping centers, factories, and other establishments. Increased facility maintenance costs would be incurred by a large number of facilities. Significant micro-economic impacts are not anticipated, and no changes in the level of employment from microeconomic effects is expected.

4.4 Summary

Compliance Costs	1979	Total
Foregone savings from rebuilding	$2,000,000 to $19,000,000 ($14,280,000 best estimate)	$280 million to $560 million
Lost service time	$268,000 to $3,800,000 ($2,380,000 best estimate)	$37 million to $112 million
Total	$2.3 million to $23 million	$317 million to $672 million

Employment effects: Some short term lay-offs possible due to lack of back up transformers. Impact may be limited to small manufacturing firms.

5.0 IMPACTS ON TRANSFORMER SERVICE COMPANIES

Maintenance of askarel transformers is usually contracted out to specialized service shops or to the manufacturer of the unit. Major rebuilding is usually performed by the manufacturer. There are approximately 250 small service companies which can perform routine transformer servicing such as gasket replacement and testing of the liquid.

Based on a telephone canvass of independent companies which service and repair transformers and on information obtained during visits to GE and Westinghouse service shops, it is apparent that exising PCB transformer requiring in-shop repair work are being serviced only by the GE and Westinghouse service operations. These two companies have reduced the number of shops presently permitted to service PCB transformers to 15 and 8, respectively, for a total of 23 shops nationwide.(1) These shops are performing the major warantee maintenance for both GE and Westinghouse and for the other transformer manufacturers. There are approximately 250 small electric apparatus service shops which repair transformers.(2) These shops no longer work on askarel transformers because of the risks of major cleanup costs and worker exposure that would be incurred by any accidental spill.

5.1 Impacts of the Proposed Regulations

The effect of the proposed regulations would be to end the practice of rebuilding transformers, but there would be no constraints on continued minor field maintenance. The effects would therefore be limited to a decreased demand for the major services performed by the service shops owned by the manufacturers. These same companies would be faced with an increased

(1) Versar Inc., PCB Activity Analysis Papers, Special Report, EPA/OTS, July 11, 1977.

(2) Electrical Apparatus Service Association Inc., 1977-1978 Yearbook, St. Louis, MO: 1977.

demand for new transformers. Assuming that manufacturing and rebuilding are equally labor intensive, there would be a change of employment from the service shops to the central manufacturing plants, but no net change in employment.

A rough estimate of the employment effects may be calculated from the total of the transformer rebuilding business. It was estimated in Chapter 4 that a minimum of 335 askarel transformers are rebuilt each year at an estimated cost of $14,000 each (70% of an average $20,000 per unit replacement cost). Assuming that one half of the cost was due to direct and indirect labor, the annual payroll resulting from this activity would be equal to (335 x $14,000 / 2 = $2,345,000). Assuming an average burdened labor rate of $30,000 per year, this payroll is equivilant to 78 full time jobs. Since the estimates of percent labor and annual wages are rough estimates, the employment impacts might be better stated as ranging from 50 to 100 jobs. It should be noted that increased employment at the manufacturing plants will offset these job losses, so any structural unemployment must be considered to be a transitional cost of the regulation.

The PCB disposal regulations require that units be drained and flushed prior to disposal. Survey of a number of users has indicated that this will usually be contracted out to experienced reliable transformer service organizations. This increased demand for the services of the larger (usually manufacturer owned) service shops may offset most of the business lost by the ban on rebuilding of askarel transformers. Therefore, the draft ban regulations are not expected to have a significant economic impact on the transformer service and maintenance industry.

The only directly identifiable impact of the draft regulations on transformer maintenance companies is the requirement that a spill prevention and control plans be prepared. Preparation of these plans and the required professional engineering review may require four man-days of effort and result in a cost of $1000 per firm for firms handling askarel transformers. This would tend to bar the small operator, resulting in minor market shifts. Cost of the required plan could equal $1000 for each of about 100 firms, or a maximum total cost of $100,000. If proforma plans were prepared under the sponsorship of a trade association or made available by a major manufacturer, the only costs to a small operator would be one day of services from a registered professional engineer to adapt, review, and approve the plans. The cost of this service should run about $250, reducing the total costs to a range of $25,000 to $100,000 for spill control plans.

5.2 Summary

	Annual Costs (1979)	Total Cost
Lost wages (temporary structural unemployment)	$0 to $2,345,000	$0 to $2,345,000
Spill prevention and control plans	$25,000 to $100,000	$25,000 to $100,000
Total	$25,000 to $2,500,000	$25,000 to $2,500,000

6.0 RAILROAD LOCOMOTIVE TRANSFORMERS

The railroads in the northeastern United States from Washington, D. C. to New York and nearby areas are electrified. The power to the locomotives and self-powered cars is carried to the equipment through high voltage ac catenaries. Transformers on the locomotives and cars reduce the voltage to that required by the traction motors. It has been standard practice to use askarel (PCB based) liquid in these transformers due to the risks that would result from spills of flammable liquid following an accident in a tunnel.

The transformers in the railroad locomotives and transit cars are known to be a maintenance problem because of the design limitations imposed by space requirements and because of the severe shock, vibration, and mechanical impacts encountered in service. Leakage of PCBs is not an unusual occurrence, and control and disposal of this leakage is impossible as it is usually sprayed on a well-drained road bed. Therefore, the railroad transformers present a significantly more severe risk of loss of PCBs to the environment than do stationary transformers.

6.1 Requirements of the Proposed Regulations

The proposed PCB ban regulations will allow continued use and maintenance of railroad locomotive and car transformers for five years, but with the following limitations:

1. Each owner of a PCB railroad transformer must report the liquid volume of each transformer to the EPA within 90 days after the effective date of the regulation.

2. Each person who uses a PCB railroad transformer must develop and implement a formal spill prevention and control plan.

3. The concentration of PCBs in the dielectric liquid in PCB railroad transformers must be reduced to below four

percent within 15 months after the effective date of the regulation. This will require that the transformer be drained and flushed to remove the PCB liquid and refilled with a non-PCB liquid.

4. Transformer liquid must be analyzed immediately after the transformer is retrofilled or the liquid is processed to decrease the concentration of PCBs. This analysis must be repeated between 12 and 24 months after each such servicing to determine whether PCBs leaching out of the windings have increased the concentration to greater than the maximum allowed by the regulation.

5. The concentration of PCBs in the dielectric liquid must be reduced to less than 0.1 percent within three years of the effective date of the regulation.

6.2 Present Ownership and Use

The ownership and use of PCB transformers installed in railroad locomotives and commuter cars is summarized in Table 6.2-1. Present plans are to convert the electric power on the Northeast Corridor from Washington, D. C. to New York City to 60 hz 25 KV by the mid-1980s. The New Haven line north of New York may be converted later in the 1980s. As a result of this change, new transformers will be required in some of the cars, and the oldest cars and locomotives will be retired from service. The effects of this voltage change on the transformers in each type of car is indicated in Table 6.2-1.

6.3 Technical Alternatives for PCBs in Railroad Transformers

PCBs have been used in railroad transformers to decrease fire hazards in accidents. European practice has traditionally been to use mineral oil in this application, and this does not appear to result in an unreasonably hazardous condition. The Japanese National Railroad retrofilled a number of locomotive transformers with silicone fluid and has operated them successfully for several years. AMTRAK has recently been testing an experimental locomotive on the Northeast Corridor (built in Sweden by ASEA)

TABLE 6.2-1

Railroad PCB Transformers

Owner*	Equip. Identification*	Equip. Type*	Number*	Effect of Voltage Change*	Transformer Capacity, Gallon	Transformer Retrofill Cost	Transformer Replacement Cost
SEPTA	E 6	COM.	46	Scrap in mid 80s	–	$ 5,000	$ 50,000
SEPTA	Silverliner 1	COM.	5	Scrap or replace trans in mid 1980s	–	5,000	134,000
SEPTA	Silverliner 2	COM.	37	Replace trans mid 1980s	–	5,000	64,000
SEPTA	Silverliner 3	COM.	20	Replace trans mid 1980s	–	5,000	64,000
SEPTA	Silverliner 4	COM.	130	None	–	5,000	65,000
" (Reading)	Silverliner 2	COM.	17	None	–	5,000	63,000
" (Reading)	Silverliner 4	COM.	104	None	–	5,000	63,000
NJ DOT	Jersey Arrow 1	COM.	34	None	–	5,000	65,000
NJ DOT	Jersey Arrow 2	COM.	70	None	–	5,000	65,000
NJ DOT	G G 1	LOCO	13	Scrap in mid 1980s	–	15,000	105,000
MTA	M 2	COM.	121	Replace trans late in 1980	–	5,000	52,000
Conn. DOT	M 2	COM.	121	Replace trans late in 1980	–	5,000	52,000
MI. DOT	E 60	LOCO	8	None	710	14,000	160,000
Conrail	G G 1	LOCO	53	Scrap in mid 1980s	–	15,000	185,000
Conrail	E 33	LOCO	10	Replace trans in mid 1980s	500	10,000	157,000
Conrail	E 44	LOCO	66	Replace trans in mid 1980s	500	10,000	142,000
Amtrak	G G 1	LOCO	40	Scrap in mid 1980s	–	15,000	185,000
Amtrak	E 60	LOCO	54	None	710	14,000	160,000
Amtrak	Metroliner	COM.	60	Replace 4 trans by mid 1980s, rest ok	255	5,000	120,000

*DeLeuw Cather-Parsons, Electric Multiple Unit Car and Locomotive Conversion for Dual Voltage - Dual Frequency Operation, Draft Report (for FRA NE Cooridor Project), September, 1977.

which uses silicone as a transformer coolant; the tests have not revealed any problems due to the use of silicone.

The Federal Railroad Administration has sponsored research by Westinghouse[(1)] and General Electric[(2)] to determine the feasibility of retrofilling existing PCB railroad transformers with silicone. The work performed under these contracts included the performance characterization of a 418 KVA transit car transformer which contained 168 gallons of askarel; draining, flushing, and retrofilling the transformer with silicone; and characterization of the transformer performance when filled with silicone. The tests conducted under these programs indicated that draining and flushing could reduce the amount of residual PCB in a transformer to a level low enough to assure that the concentration of PCB in the silicone liquid would remain below four percent. The use of silicone as a replacement for PCB results in a transformer that runs hotter by perhaps five to ten degrees C. This increase in temperature will not necessarily decrease the service life of a transformer, as the solid insulation used in transformers may degrade less rapidly in silicone than in PCBs.

PCBs and trichlorobenzene are selectively adsorbed from silicone liquid by activated carbon. Dow Corning recently demonstrated that filtration of silicone from a retrofilled PCB transformer that had been in service for ten months reduced the concentration of PCBs from 2.53% to 472 parts per million.[(3)] For those transformers equipped with a pump, it may be

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(1) Walsh, E.J.; Voytik, D.E.; Pearce, H.A. (Westinghouse Electric Corp.) Evaluation of Silicone Fluid for Replacement of PCB Coolants in Railway Industry, Draft Final Report, Report No. DOT-TSC-1294, July, 1977.

(2) Foss, Stephen D.; Higgins, John B.; Johnston, Donald L.; McQuade, James M. (General Electric Co.), Retrofilling of Railroad Transformers, Draft Final Report; Contract DOT-TSC-1293, July, 1977.

(3) Dow Corning Corporation, Removal of PCB from Dow Corning 561(R) Transformer Liquid by Charcoal Filtration, undated.

possible to install a cartridge filter containing activated carbon in the liquid circulation piping. The filter would continually scavenge residual PCBs from the silicone after most of the PCBs had already been replaced when the transformer was retrofilled. This procedure might assure that the concentration of PCBs in the silicone would not increase to concentrations above the 1000 ppm required by the proposed regulation.

The decontamination of silicone transformer liquids is still in the experimental testing stage. Westinghouse Electric Corporation has reportedly applied for a patent on the process of using activated carbon to remove PCBs from silicone. No results have been made public on techniques to remove PCBs from hydrocarbon transformer liquids, although RTE Corporation is reportedly doing research in this area.

6.4 Cost Impacts of the Proposed Regulations

It is not known at this time whether the liquid used to replace the PCBs will be silicone or a high fire point hydrocarbon liquid. However, silicone has been extensively tested and is the most expensive of the alternatives; accordingly, costs based on the use of silicone provide an upper bound estimate of the costs of retrofilling.

Silicone liquid prices range from $11.00 to $14.50 per gallon. Recent charges for field retrofilling of transformers have run from $20 to $40 per installed gallon, including disposal of the PCBs and contaminated flushing liquid and analysis of the retrofilled liquid for PCBs. Since the retrofilling of locomotive transformers will be done only in a few well-equipped shops, the installed costs should not exceed $20 per gallon of silicone.

Depending on the specific design and use, the average service life of railroad transformers is from four to 30 years. Failed transformers are presently rebuilt by the manufacturer for approximately 25% of the cost of a new transformer. Rebuilding requires approximately 4-6 weeks while deliveries of new replacement transformers require 12 to 18 months.

The major cost impact is expected to result from the retrofilling and decontamination of the transformers. The concentration of PCBs can be reduced to the required limit of 4% by draining the askarel, flushing the transformers, and replacing the liquid with a suitable high fire point transformer liquid such as silicone. Based on the retrofill costs presented in Table 6.2-1, the costs incurred by the railroads in the first 15 months following the effective date of the regulation will total $7,043,000.

Reduction of the concentration of PCBs to 1000 ppm by three years after the effective date of the regulation would require that a transformer be retrofilled an additional two times or that the liquid be processed at least twice to remove PCBs. No estimates have been made by transformer companies as to the cost of processing to remove PCBs. The cost should be similar to the cost of retrofill less perhaps 90% of the cost of the replacement liquid. The cost of processing as calculated in Table 6.4-1 would therefore be about 37% of the cost of retrofilling. Additional analyses would be required 12 to 24 months after each retrofilling or processing at a cost of about $75 per analysis. The total cost of reducing the PCB concentration in the retrofilled transformers would therefore include both the cost of the processing and the additional cost of analyzing the liquid after the transformer is returned to service. The additional cost to the railroads of achieving this low level of PCBs is calculated in Table 6.4-1 to be $5,460,000. These costs will be incurred during the years 1980 and 1981.

Spill prevention and control plans will have to be prepared by each of the seven owners. Because of the complexity of railroad operations, these plans will cost several thousand dollars to prepare and implement for a total industry expense of perhaps $20,000.

Finally, the initial reporting of the identity of the PCB equipment and the liquid capacity of each transformer will cost several dollars per unit, for an additional cost of perhaps $5,000.

TABLE 6.4-1

Cost of Processing Retrofilled Railroad Transformer Liquid to Reduce the Concentration of PCBs

Cost of retrofill		$ 20.00 per gallon
less cost of silicone	-	12.00 " "
less cost of flushing liquid	-	.42 " "
less cost of incineration of 2 gallons	-	3.00 " "
Labor, overhead, and analysis costs		4.58 per gallon
plus .1 gal silicone per gal of transformer capacity .1 x 12.00 =		1.20
plus 2 lb carbon per gal @ .60/lb		1.20
plus disposal of 3 lb wet carbon per gal @ .15/lb		.45
TOTAL PROCESSING COST		$ 7.43 per gallon

Cost of processing as a fraction of cost of retrofilling =

7.43/20.00 = 37%

Cost of processing retrofilled transformers:

Analysis for PCBs* 1,009 units @ $75		$ 75,675
Processing	$7,043,000 x .37	2,616,000
Analysis*		75,675
Second processing		2,616,000
Analysis*		75,675
Total cost of processing to meet 1,000 ppm limit on PCBs		$5,460,000

*Analysis conducted 12 to 24 months following previous retrofill or processing.

The proposed regulation authorizes continued use of the retrofilled transformers for only five years from the effective date of the registration. It is assumed that a review of the environmental impact of losses from the retrofilled units will result in this authorization being extended indefinitely.

6.5 Economic Impacts of the Proposed Regulations

The required retrofill and processing program should cost less than 20% of a comparable program to replace all of the transformers within the next several years, and the retrofill program should avoid any significant disruptions of railroad service on the Northeast Corridor.

All of the affected owners of PCB railroad transformers are governmental or semi-governmental corporations which are running operating deficits as summarized in Table 6.5-1. These deficits, of over $800 million per year, are presently being covered by subsidies from tax revenues.

The retrofill and processing program is not expected to result in significant service disruptions, and no effect on railroad operating employment is anticipated. The retrofill and processing programs are expected to generate a considerable demand for labor. Calculated total labor and overhead costs are summarized in Table 6.5-2. This would be the equivalent of 165 man years of employment, assuming a burdened labor rate of $30,000 per man year. Additional employment would result from the increased production of the silicone liquid and activated carbon and increased disposal incineration services.

6.6 Summary

Cost Impacts:

	Amount	Timing
Cost of retrofill program	$7,043,000	1979
Cost of processing program	5,460,000	1980-1981
Reporting	5,000	1979
Spill prevention plans	20,000	1979
	$12,528,000	

TABLE 6.5-1

1976 Operating Losses of Railroads Using PCB Transformers

Railroad	1976 Operating Results $ millions	Total Loss 1976 $ millions
CONN DOT[1]	19.1 operating deficit 3.2 MTA depreciation	22.3
SEPTA[2]	1.25 operating loss 6.38 depreciation	7.6
NJ DOT[3]	38.5 subsidy	38.5
AMTRAK[4,5]	441 total loss other than NE corridor maint. 37.5 1/2 of $75 million loss for NE Corridor operation	478.5 (Est.)
CONRAIL[6]	205.5 losses for 9 months, April-Dec. 1976	280 (Est.)
	Total Losses	$ 826.9

(1) Metropolitan Transit Authority, Annual Report, 1976, p. 44.

(2) SEPTA, Report to the Public and Financial Statements for 1974 and 1975 - Statement of Operations

(3) NJ Department of Transportation, Highlichts of Activities, 1976, p. 14.

(4) Amtrak, 1976 Annual Report, pp. 6, 7, 28.

(5) Amtrak, Five-Year Corporate Plan, 1977, p. 158.

(6) Consolidated Rail Corporation, Annual Report, 1976, pp. 1, 14, 18.

TABLE 6.5-2

Labor and Overhead Costs of Retrofill and Processing Program for Railroad Transformers

Total capacity of transformers: $7,043,000 retrofill cost/$20 per gallon =	352,150 gallons
Labor and overhead cost of each retrofill or processing @ 4.58 per gallon = 352,150 x 4.58 =	$1,613,000
Total labor costs for one retrofill and two processing of each transformer	4,839,000
Labor and overhead costs of 3 additional analyses per transformer @ 50% of $75 test price: 1,009 units x 3 tests per unit x $75 per text x 50% =	113,000
TOTAL LABOR AND OVERHEAD COSTS	$4,952,000
TOTAL LABOR DEMAND @ $30,000 PER BURDENED MAN YEAR	165 man years

Economic Impacts:

Increased costs are expected to be paid from government subsidies.

Employment:

An increased employment totaling at least 161 man years is anticipated over three years.

7.0 OIL FILLED POWER AND DISTRIBUTION TRANSFORMERS

PCB-based askarel liquids have historically been offered as a higher priced alternative to the petroleum based transformer oil used in most liquid cooled transformers. The PCB and oil filled transformers were manufactured in the same facilities, and many opportunities were present for the contamination of transformer oil with PCBs. In addition, field servicing of PCB and oil filled transformers has been performed using the same equipment providing additional potential for contamination of the oil by PCBs residual in the equipment from previous uses.

There are no reported incidents where PCBs have been intentionally added to oil filled transformers, and such an occurrence would be unlikely because of the higher cost of PCBs relative to oil. However, analysis of oil taken from transformers has indicated that a significant number are contaminated with PCBs at a concentration above 50 ppm. These contaminated transformers would be subject to certain requirements under the provisions of the proposed regulations.

7.1 Requirements of the Proposed Regulations

Transformer oil contaminated with PCBs in concentrations above 50 ppm will have to be disposed of by high temperature chemical waste incineration. However, transformers contaminated with PCBs in the range of 50 to 500 ppm will not have to be marked, nor will there be any restrictions on servicing, rebuilding, or disposal of the drained transformers.

7.2 Estimation of the Extent of Transformer Oil Contamination by PCBs

Number of Transformers

Available data on US transformer production and sales do not differentiate between oil filled and askarel transformers, but indicate only the total production of liquid filled units of various sizes and types. The most recent data, for 1972, are summarized in Table 7.2-1, below:

TABLE 7.2-1 (1)

Number of Liquid Cooled Transformers Manufactured: 1972

Class	Quantity
Distribution Transformers	
Overhead and Pole Mounted	1,253,400
Pad Mounted	231,600
Small Power Transformers (less than 10,000 KVA)	13,000
Secondary Unit Substation Transformers	3,400
Large Power Transformers (above 10,000 KVA)	3,400
Total	1,504,800

The number of overhead and pole mounted transformers currently in service is not accurately known, but an estimate of 30,000,000 units is usually accepted in the industry. These transformers contain an average of about 16 gallons of oil each. Very few of these transformers have ever been filled with PCBs, and many of them were built in manufacturing plants which made only this type of transformer and never handled askarel. Therefore, it is unlikely that these transformers were contaminated with PCB when manufactured, and the units are seldom serviced in the field. The failure rate of these pole mounted transformers is about 0.5% per year,(2) and most failed units are rebuilt. No data have been found concerning the extent of PCB

(1) Bureau of the Census, Electrical Measurement and Distribution Equipment, Report No. MC72(2)-36A, Table 6A.

(2) Consensus of opinions of transformer manufacturers contacted by Versar by phone, 1978.

contamination of this type of transformer.

The remaining 250,000 liquid cooled transformers manufactured in 1972 included about 5,000 askarel units. Assuming that there are 140,000 askarel units in service and that the ratio of oil coooled to askarel transformers has always been 40 to 1, as was the case in 1972, then the calculated number of oil cooled transformers other than pole mounted would be 6,850,000.

Alternatively, it could be argued that since the ratio of the total number of pole mounted transformers to the 1972 production of this type of unit is 30,000,000 to 1,253,000, that this ratio times the 1972 production of other types of liquid filled transformers would give the number of other transformers presently in use. By this method of calculation, there are 6,000,000 non-pole mounted liquid filled transformers in use, minus the 140,000 askarel units, or a total of 5,850,000 oil filled units.

Another method of deriving the total number of oil-filled transformers is to calculate the production of transformers from available data on sales of transformer oil. The annual sales of transformer oil from 1968 through 1977 are summarized in Table 7.2-2, below:

TABLE 7.2-2

Annual Sales of Transformer Oil in the U. S. (1)

Year	Sales: Million Gallons
1968	70
1969	72
1970	75
1971	76
1972	82
1973	94
1974	96
1975	70
1976	75
1977	78 (est.)

(1) Rouse, T.; Raab, E. (General Electric Co.), U. S. Transformer Oil Supply and Demand, 1975-1985, Interim Report, Palo Alto, Calif.: Electric Power Research Institute (Report No. EL-303), Nov. 1976.

These data suggest that the sales of transformer oil have increased geometrically at a rate of 5.4% per year (average increase) from 1968 through 1974. Assuming that this growth rate describes oil sales prior to 1968, total oil sales through 1974 would have been 1.8 billion gallons, or a total sale of two billion gallons up to the present. Since few transformers have ever been scrapped and since transformer oil has been routinely reclaimed for reuse, the total amount of oil in service is probably about 90% of the total amount produced, or 1.8 billion gallons.

Assuming that the pole mounted transformers require an average of 16 gallons of oil per unit, the 1972 transformer production required 20 million gallons of oil for the pole mounted transformers and 60 to 62 million gallons (depending on the amount of oil used in transformer maintenance) to fill the remaining 245,000 oil filled transformers. This gives an average oil capacity for non-pole mounted transformers of 250 gallons per unit which is not significantly different than the 300 gallons per askarel transformer used in previous calculations. The thirty million pole mounted transformers contain about 500 million gallons of oil at 16 gallons per unit. The remaining 1.3 billion gallons of oil would fill 5,200,000 transformers having an average capacity of 250 gallons. Since improved transformer designs have reduced the quantity of oil required per transformer over the years, this figure perhaps overstates the number of transformers in service, but an estimate of 5,000,000 transformers other than pole mounted units is perhaps reasonable based on the available data.

Ownership of Transformers

Most of the power and substation transformers are owned and maintained by utilities. The ownership of the small power transformers and the pad mounted distribution transformers depends on the policies of individual utilities, and there does not appear to be any standard policy that applies across the country. Almost all the large distribution transformers are owned by utilities; those owned by industrial plants and large buildings are generally smaller units. Estimates by knowledgeable industry representatives contacted by Versar suggest that perhaps 80% of the total volume of oil in transformers other than pole mounted units is in units owned by utilities.

Number of Contaminated Oil-Filled Transformers

The only available information on the extent of PCB contamination of oil-filled transformers is the results obtained by one major transformer manufacturer which analyzed the oil from 55 units. This oil was taken from distribution transformers and power transformers, and in a few cases from bushings on transformers. Based on the results of quantitative analysis for PCBs in the oil, 25 of the 55 transformers were contaminated with PCBs in excess of 50 ppm in the oil. The concentration of PCBs in the samples varied from 5 ppm to 155 ppm. This sample was taken on the basis of convenience, and probably does not represent an unbiased sample of all oil filled transformers presently in use. In addition, it is not known how any biases may affect the accuracy of extrapolating the above data to all oil filled units. If this sample were unbiased, it would indicate that 45% of all oil filled transformers were contaminated with PCBs in excess of 50 ppm. The 95% confidence interval for this estimate is from 32% to 59% of the transformers presently contaminated with PCBs above 50 ppm.

No data is available on possible contamination of the 30 million pole top transformers, and it is not possible to calculate the effect of the PCB ban regulations on these units until this information is available. Based on the results of the small and possibly biased sample described above, it would appear that possibly as many as 2,200,000 oil filled transformers could be contaminated with PCBs at concentrations above 50 ppm, that none of these transformers are contaminated at levels above 500 ppm, and that the transformers contaminated at levels above 50 ppm contain about 600,000,000 gallons of oil. At an average concentration of 80 ppm PCBs, this would suggest that the material affected by the regulations consists of 384,000 pounds of PCBs dissolved in 4.8 billion pounds of oil.

7.3 Costs of Complying with the Proposed Regulations

The proposed regulations do not affect the continued use and maintenance of oil filled transformers that are contaminated with PCBs in concentrations below 500 ppm. Disposal of oil contaminated with PCBs in excess of 50 ppm will be allowed only by approved chemical waste incineration. Compliance with these regulations would require that contaminated transformers be identified by analyzing the oil for PCBs, and that the oil from these transformers be disposed of in a special incinerator. Costs will be incurred for sampling, analysis, and disposal.

The cost of disposal of PCB liquids was investigated in an EPA sponsored study of the economic impacts of the PCB Marking and Disposal Regulations.[1] The following costs for disposing of contaminated transformer oil are developed from these previously reported costs.

Sampling and Analysis

Determination of the PCB content of transformer oil requires that a sample of the oil be analyzed by an experienced laboratory using a gas chromatograph equipped with an electron capture detector. Most liquid filled transformers have a provision for obtaining a sample of the oil. Assuming that a transformer has a drain cock which can be used to obtain a sample of the oil, the cost of obtaining the sample should be little different than the cost of applying a label calculated for the marking regulations.[1] Present commercial charges for the required analysis are $60 per sample for quantity orders of six to eleven samples analyzed at one time.[2] Order processing and shipping costs of $50 per order of ten samples would be incurred by the transformer owner, resulting in a total cost of analysis of $67 to $80 per transformer in a routine sampling and analysis program.

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(1) Versar Inc. Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs, (EPA Report No. 560/6-77-013), Springfield, Va.: National Technical Information Service (NTIS No. PB-267 833/2WP), April 26, 1977.

(2) Versar Inc., Price Schedule - Quantitative Analysis of PCBs in 10-C Transformer Oil (Price Sheet 100), Springfield, Va.: May 1, 1978.

$2 to $15 sampling; $5 order processing; $60 analytical services.

Disposal

The incineration of oil contaminated with PCBs in the range of 50 to several hundred parts per million would not require any additional fuel, but the costs of facility amortization, maintenance, operation, and capital would be the same as for a unit burning pure PCBs. The cost of incinerating the oil depends critically on the value of the material as fuel in an incinerator handling fuel-poor materials such as pure PCBs or shredded capacitors. Present practice is to fuel such incinerators with chemical wastes which have a high fuel value. Present charges for the incineration of PCB solids run about $0.15/lb.,(1) which reflects the availability of essentially free fuel. Therefore, under present conditions, there is little demand for the PCB contaminated oil as a fuel for PCB incinerators, and the oil has no economic value as a fuel in such units. It is possible that the demand for incineration of capacitors will increase to such an extent that the fuel requirements cannot be met by waste solvents; the contaminated transformer oil may then have some economic value as a fuel, and the incineration costs would be expected to decrease to reflect this value.

The use of the contaminated oil in any chemical waste incinerator other than one which is burning PCBs would result in additional analytical costs and record keeping requirements. Because of the limited number of PCB incinerators that will be in use, it is not likely that a competitive market for contaminated oil for use as fuel in PCB incinerators will develop and the charges for incinerating contaminated oil would then be controlled by the price that could be charged by a special purpose oil incineration unit. A cost analysis for such a special purpose incinerator is summarized in Tables 7.3-1 and 7.3-2. This unit is of a size equivalent to the incinerator used to evaluate the disposal costs for PCBs and capacitors resulting from

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(1) ENSCO, General Information ENSCO-PCB-001 Rev. 3-78, El Dorado, Arkansas: March, 1978.

TABLE 7.3-1

Preliminary Cost Estimate for a Chemical Waste Incinerator for Transformer Oil Contaminated with Low Concentrations of PCBs

Plant Capacity: 4,000 lb oil/hr. (500 gal/hr.)

Equipment		Installed Cost
Combustion furnance, after burner, associated ducting		$ 1,000,000
Scrubbing Equipment, Tankage, Pumps		500,000
Stack, Foundations, Site and Site Preparation		150,000
Activated Carbon Filtration System		250,000
Settling Pond		100,000
	Subtotal	$ 2,000,000
Piping and Valves @ 25%		500,000
	Subtotal	$ 2,500,000
Engineering @ 7%		175,000
	Subtotal	$ 2,675,000
Contingency @ 20%		535,000
	Total	$ 3,210,000

TABLE 7.3-2

Annual Operating Costs for Contaminated Oil Incinerator

Plant Capacity: 500 gal/hr. (4,000 lb/hr.)

Operating Factor: 7,300 hours/year

Annual Capacity: 3,650,000 gal/year (30,000,000 lb oil/year)

Capital Investment: $3,210,000

Variable Costs:	
Direct Operating Labor, 2 men/shift @ $10/hr.	$ 175,000
Supervision & Administration @ 50% of direct operating labor	87,000
Activated Carbon System (1)	122,000
Maintenance @ 20% of capital investment	640,000
Power: 100,000 KWH @ 3¢/KWH	3,000
Sampling and Analysis	100,000
	$1,127,000
Fixed Costs:	
Return on Invested Capital (10%)	321,000
Capital Recovery (10 years @ 10%)	321,000
Taxes and Insurance (4% of capital cost)	128,000
Total Fixed Costs	$ 770,000
Total Annual Costs	$1,897,000
Cost/lb. contaminated oil	$ .0632
Cost/gal. contaminated oil	$ .51

(1) This includes replacement of 43,000 lb/yr. of spent activated carbon and incineration of the spent material by a general purpose chemical waste incineration.

the "PCB Disposal Regulations." The incineration cost of \$.0632 per pound of contaminated oil is similar to the lower bound estimates of probable market prices reported informally by presently operating chemical waste incineration companies. Transportation costs incurred in delivering the oil to the incinerator would be about \$.02 per pound based on costs previously calculated for askarels.[1]

Compliance Costs

The effect of the proposed regulations will be to require the incineration of oil contaminated with PCBs. Control of the disposition and use of used transformer oil will require the analysis of oil for PCBs. Analysis of oil for PCBs will only be economically justified if the expected value of the savings in disposal costs if the oil is not contaminated exceeds the cost of analysis. For instance, it would cost \$75 to sample and analyze the oil in a transformer that has a 45% expectation of being contaminated with PCBs at a concentration in excess of 50 ppm. The value of oil to the transformer owner is zero if the concentration of PCBs is less than 50 ppm (i.e., a commercial collector will be willing to pick it up and haul if away for free). Disposal would cost \$0.0832 per pound for transportation and incineration if the oil is contaminated above 50 ppm. The expected savings to be obtained by analyzing the oil would be equal to (0.0832/lb × number of pounds of oil × probability the oil is not contaminated with more than 50 ppm PCBs) minus the cost of the analysis. Analysis is therefore a good investment for large transformers and those transformers less likely to be contaminated with PCBs. This relationship is presented in graphical form in Figure 7.3-1.

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(1) Versar Inc., Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs, (EPA Report No. 560/6-77-013), Springfield, Va.: National Technical Information Service (NTIS No. PB-267 833/2WT) April 26, 1977, pp. 3-19.

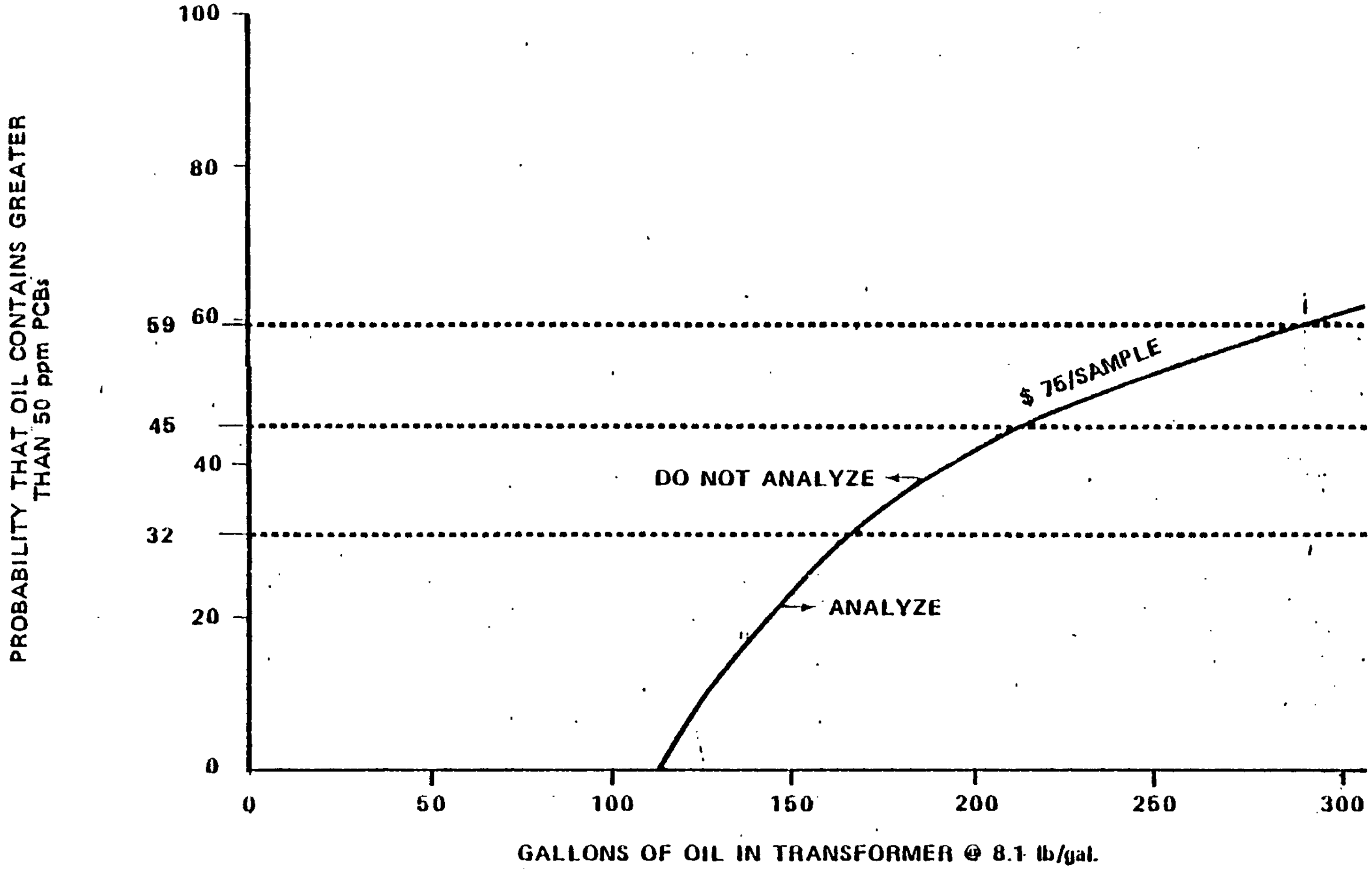

FIGURE 7.3-1 DECISION CRITERIA FOR ANALYZING TRANSFORMER OIL FOR PCBs BEFORE DISPOSAL

Although the average amount of oil per transformer has been calculated to be about 250 gallons, no information is available on the distribution of transformers by oil capacity. As a reasonable guess, the median transformer capacity might be 150 gallons. A lower bound estimate of the fraction of transformers contaminated is 32%. At this level, testing would be justified for approximately one-half of the oil filled transformers other than pole mounted units. These larger transformers would account for perhaps 75% of the total oil. Incineration would therefore be the required disposal method for all of the 25% of the oil in the small transformers and 45% of the rest of the oil. The resulting analytical and disposal costs would then be calculated as shown in Table 7.3-3, below:

TABLE 7.3-3

Testing and Disposal Costs for Transformer Oil

Assume: 32% of all transformers contain more than 50 ppm PCBs.

	Size of Transformer	
	> 150 gal.	< 150 gal.
Number of transformers	2,500,000	2,500,000
Analytical Costs @ $75	$187.5 million	0
Oil in transformers	7.9 billion lb.	2.6 billion lb.
Oil requiring incineration	2.5 billion lb.	2.6 billion lb.
Incineration cost @ $.0832	$210 million	$215 million

Total analytical and incineration costs: $612.5 million

The upper bound estimate of the fraction of transformers that are contaminated was calculated to be 59%. At this level of contamination, testing would be justified only for transformers containing more than 270 gallons of oil. This criteria may result in the testing of perhaps 20% of all transformers containing 50% of all of the oil. The calculation of the resulting analytical and disposal costs are summarized in Table 7.3-4:

TABLE 7.3-4

Testing and Disposal Costs for Transformer Oil

Assume: 59% of all transformers contain more than 50 ppm PCBs.

	Size of Transformer	
	> 270 gal.	< 270 gal.
Number of transformers	1,000,000	4,000,000
Analytical Costs @ $75	$75 million	0
Oil in transformers	5.25 billion lb.	5.25 billion lb.
Oil requiring incineration	3.1 billion lb.	5.25 billion lb.
Incineration cost @ $.0832	$257 million	$437 million

Total analytical and incineration costs: $769 million

By comparison, arbitrarily incinerating all 10.5 billion pounds of possibly contaminated transformer oil would cost $880 million. Assuming that no additional contamination of transformer oil by PCBs will occur, replacement of the oil in any contaminated oil filled transformer would be expected to reduce the concentration of residual PCBs to well under 50 ppm.

The rate at which these disposal costs will be incurred depends on the rate of disposal of contaminated transformer oil. The regulations do not prohibit the processing of contaminated oil so long as it is returned to the same transformer it was taken from. Processing losses are expected to be low, so most of the contaminated oil would not be disposed of until the transformers are retired from service due to failure. If one-half of the PCB contaminated transformers will be scrapped or refilled with new oil within the next twenty years, and the rate of such oil disposal does not depend on the age of the transformers, the rate of disposal would be 3.4% per year (i.e., a failure rate of 3.4% per year implies a 20-year half life). Based on these assumptions, annual analytical and disposal costs would be from $21.4 million to $26.1 million in 1979, and decrease in future years by 3.4% per year as the number of contaminated transformers in service decreases by this fraction.

7.4 Summary

Analytical and Disposal Costs:

1979 -	$21.4 million to $26.1 million
Succeeding Yrs -	3.4% less each year
Total -	$612 million to $769 million

Employment Effects:

Analytical services - Assuming that 50% of the cost of the analysis is for labor and that the burdened labor rate is $30,000 per year, the analytical costs of $75 million to $187 million imply a total labor demand of 1250 to 3117 man years. Initial demand would be 3.4% of this, or an increased employment in 1979 of 42 to 106 jobs.

Disposal - The disposal cost analysis presented in Table 7.3-2 assumed that direct labor and supervisor labor costs were 14% of the cost of disposal. At the labor rates assumed in the table, disposal demand of $425 million to $694 million would imply a labor demand at an average rate of $30,000 per year of ($435 million x .14/$30,000/man year = 2030) to ($694 million x .14/$30,000/man year = 3239) man years of labor.. At a demand rate of 3.4% during the first year, this implies an increased employment of 69 to 110 jobs in the disposal industry in 1979.

8.0 MINING MACHINERY

The only known use of PCBs in electric motors was by Reliance Electric Company of Cleveland, Ohio, which used PCBs as a coolant in certain specialized motors. These motors were used by Joy Manufacturing Company of Franklin, Pa., in several types of mining machines built during the late 1960s and early 1970s. The motors require rebuilding every few years. Although PCBs are seldom lost from the motor housing when the motor fails, such loss of fluid would result in substantial exposure of the machine operator to PCBs. The proposed regulations allow a limited period of time for conversion of the machines to motors which do not use PCBs.

8.1 Requirements of the Proposed Regulations

All of the PCB motors must be removed from service in mining machines by December 31, 1981. The motors on the continuous miners may be rebuilt as PCB motors for one year after the effective date of the regulations. The motors on the loaders must be rebuilt as dry type motors when the motors are returned to the shop for servicing. Continued use of PCB motors on mining machines must be reported to EPA within 90 days after the effective date of the regulation, and a spill response plan must be developed and approved by a registered professional engineer for each user installation.

8.2 Ownership and Use of PCB Mining Machinery

Joy Manufacturing Company was the sole U.S. producer of mining equipment which used PCBs as a motor coolant. Both continuous miners and loaders were built using PCB motors. Table 8.2-1 summarizes the production statistics and the present use status of these machines.

One small coal mining operation located in Pennsylvania is operating the three remaining model CU43 continuous miners known to be

Table 8.2-1

Production Statistics & Present Use Status of PCB-Cooled Mining Machines

Machine	Production Dates	Number of Machines Built	Number of Machines Still in Service	Number of Liquid-Cooled Motors Per Machine	Number of PCB-Cooled Motors Still In Service	Number of Gallons of PCB Used Per Motor
Continuous Miner Model CU43	1961-1966	17	3	3	1	4
Continuous Miner Model 9CM	1967-1970	57	~ 15	3	~ 45	5
Loader Model 14BU10	1971-1973	533	~533	2	652	4
Spare Motors for Model 14BU10	1971-1973	34 motors		–		

still in service. Two of these machines presently use silicone-cooled motors while the third machine has only one PCB motor remaining - i.e., two of the three motors are silicone-cooled.

Fifty-four of the fifty-seven model 9CM continuous miners built by Joy Manufacturing have been located in the course of this investigation. Thirty-five of those located are idle (standby service or stored as a source of spare parts), thirteen are being used to mine coal, three are in uses other than coal production (e.g., cutting overcasts and clearing air courses), two are used as spare equipment, and one is being used in a training program at a vocational school. Two of the three model 9CM continuous miners that have not been accounted for were reportedly sold. Therefore, it is estimated that a total of approximately fifteen units are still in service.

The PCB loaders were sold to eighty-eight different mining operations, the majority of them small coal mines. Sixty of these mines use three or fewer loaders and, based on a survey of thirty-six mines, it is estimated that nearly all of these loaders are still in service.

The motors in loaders generally require rebuilding every 18 to 24 months, the time to failure depending upon operating conditions. The motors used in continuous miners usually require rebuilding every 12 weeks because continuous miners are operated under relatively severe conditions. Rebuilding, from the time the motor is removed from service until the machine is returned to service, usually requires one to two weeks.

Both the continuous miners and the loaders are used in underground mines. Joy Manufacturing reported that a few of the machines were originally sold for use in potash mines, but all of the mines that were identified in the course of this survey were coal mines. The continuous miners gouge the coal off the face of the seam and continuously load it onto shuttle cars which haul it to a conveyor. After the miner has driven into the seam about twenty feet, it is moved to a nearby section while the roof that it exposed is bolted. The loaders are used in conventional mining in which the coal face is drilled and undercut by a drilling machine. After the coal is blasted, the loader scoops it up and loads it into a shuttle car. Roof bolting is also required in this type of mining operation. In either continuous or conventional mining, an entire section with all associated equipment will be idle if the miner or loader is out of service and there is no stand-by capacity, as is generally the case for small mining operations.

The output of conventional and continuous mining operations has been conservatively estimated at 250 tons of coal per section per shift (eight hour working day). Given two shifts per day, each coal mining technique produces over $10,000 worth of coal per day (valued at current prices). Conventional coal mining operations generally require eleven to thirteen men; continuous mining operations require only eleven men.

8.3 Compliance Costs

Loaders

The PCB-cooled motors presently used in loaders can be readily replaced or converted to air-cooled (i.e., dry) motors when serviced every 18 to 24 months. The cost of replacement with a new air-cooled unit is $6,258 per motor or $12,516 per loader. However, conversion kits are available from Reliance Electric Company, sole motor supplier to Joy Manufacturing Company, for $3,100 per kit. Each kit converts one motor, and each loader uses two motors.

Over the past few years, Joy Manufacturing has been converting the motors on loaders to air cooling. At a PCB hearing in Chicago on July 19, 1977, Joy Manufacturing stated that they had converted 353 of these motors. An additional 95 motors had been converted as of the middle of November, 1977, leaving 652 loader motors to be converted (note that this figure includes the thirty-four spare loader motors). Joy Manufacturing estimates that all remaining PCB-cooled loader motors can be converted to air-cooled by the end of 1981. The cost of this conversion is $3100 per motor, resulting in a total cost of about $2 million to convert the remaining 652 motors.

Continuous Miners

The PCB and silicone-cooled motors in miners present transition problems. As a result of the proposed regulations, the market for used PCB-cooled continuous miners equipment will virtually disappear. Therefore, various mining operations will be confronted with obsolete equipment perhaps prematurely, resulting in substantial capital losses which depend upon the remaining useful life of the equipment.

All but one of the nine motors in the Joy Manufacturing Model CU43 continuous miners that are still in service have been converted to silicone coolants by the owner. However, it has recently been found that silicone vapors may deactivate the electrodes in methane detectors which are used to monitor the ambient air conditions in underground mines. Thus, silicone fluids may not be acceptable where such detectors are used.

Model 9CM continuous miners cannot be refitted with air-cooled motors due to space limitations, nor can such equipment house converted motors. Therefore, unless a satisfactory replacement heat transfer liquid can be developed for use in motors, this equipment must be scrapped and new equipment purchased.

The value of the continuous miners is best approximated by its value of $40,000 on the used equipment market. The new replacement machines will have a much higher price, but will be more productive and require less maintenance. Historically, mining equipment has become obsolete after about ten years of service, and most mining operations tend to upgrade their equipment prior to the end of its useful life. Since 1970 was the last production date of PCB-cooled continuous miners by Joy Manufacturing Company, all such equipment is likely to reach obsolescence by the proposed compliance date - i.e., 1981. Replacement of this equipment, therefore, may occur regardless of the proposed PCB ban regulation. However, mining operations will no longer be able to employ the obsolete equipment as spare equipment to take up the slack resulting from machine servicing, nor will they be able to sell it in the used equipment market. Forced scrapping of this equipment prior to the end of its useful life can result in significant costs (losses) to a mining operation, depending upon the remaining useful life of such equipment.

Six of the eight companies using the PCB miners are relatively small, with production of from .7 to 4.2 million tons per year. The other PCB miners are in use in mines owned by conglomerates which produce considerably greater tonnage of coal. Any costs which are likely to be borne by these companies as a result of the lost opportunity to sell their PCB equipment in the used market will have little or negligible impact on the market price of coal. This stems from the small market share of U. S. coal now mined by PCB-cooled continuous miners and the ability of competitors to expand operations. Furthermore, Versar estimates that whatever costs are incurred by these eight mining companies will not result in company closures and subsequent losses of employment.

Table 8.3-1 summarizes the possible economic costs of the proposed PCB ban regulation to the eight mining companies using the continuous miners. Note that only PCB-cooled continuous miners that are still in service are considered in this analysis because it is not known how many of the remaining forty-one continuous miners located have a positive market value and useful life. Assuming that forty of these miners can be sold in the used equipment market (i.e., omitting the one continuous miner that is being used by the vocational school), the additional economic costs would be a maximum of ($40,000 x 40 = $1,600,000). In no case does the economic impact on any company exceed one percent of the annual value of the coal mined by the company.

TABLE 8.3-1

Cost Impact of Forced Retirement of PCB Continuous Miners

Company No.	Number of Continuous Miners Model CU43	Number of Continuous Miners Model 9CM in Service	Opportunity Cost Due to Absence of Used Equipment Market
1*	1 (1)	0	$ 40,000
2*		3	$ 120,000
3*		2	$ 80,000
4*		1	$ 40,000
5		1	$ 40,000
6*		1	$ 40,000
7		2	$ 80,000
8*		5	$ 200,000
TOTAL	1	15	$ 640,000

(1) Note that company no. 1 operates three model CU43 continuous mines but only one machine still uses PCBs as a motor coolant; and only one motor of the three used to operate the machine does contain PCBs - i.e., the other two motors employ silicone as a coolant.

* Small producer (less than five million tons per year total company production).

Reporting Costs

The proposed regulations would require that the EPA be informed of the identity and ownership of each PCB mining machine within 90 days of the effective date of the regulation, and that the owners maintain current records of the machinery and report changes of ownership to the EPA. There are approximately 96 mining companies which own PCB machines. The information required for the initial report should be available from inventory records, and preparation of the report should require no more than one to two days per company. Assuming an average of one and one-half man days per company report, and an average burdened labor rate of $30,000 per man year, the reporting requirement will result in costs of (96 companies x 1.5 man days per company x $30,000 per man year/240 man days per man year = $18,000). The other record keeping requirements are similar in scope to normal inventory procedures and should not result in significant additional costs to the mining companies.

Spill Prevention and Control Plans

A formal contingency plan will be required of each company which operates PCB mining machines. This plan will have to be specific for each company, and will have to be reviewed and approved by a registered professional engineer. A sample plan for these machines will be prepared by Versar Inc. under a contract sponsored by the U. S. Bureau of Mines. Using this published plan as a basis for the preparation of a specific company plan should reduce the effort to one day of company time and one day of professional engineering services per company. This will result in costs to the mining companies of (1 man day x $30,000 per man year/240 man days per man year + 1 day consulting x $250 per day = $375 per company). For the entire industry, total costs will be (96 companies x $375 per company = $36,000).

8.4 Summary

Cost Impacts:

Loaders -		
Rebuild: 652 motors @ $3100	$ 2,021,000	
Continuous Miners -		
Premature scrapping: 16 operating miners @ $40,000	640,000	
40 other miners @ 0 - $40,000	0	- 1,600,000
Reporting Costs -	18,000	
Spill prevention and control plans	36,000	
Total	$ 2,715,000	

[Plus up to $1,600,000 additional. All costs will be incurred in the period 1979 through 1981.]

Production and Price Impacts:

No loss of coal production is anticipated. Since coal prices are set by competitive market forces and are usually set by long term contracts, it is expected that the additional costs of these regulations will be absorbed by the mining companies as reduction in profits.

Employment Effects:

No reduction in mine employment is anticipated. The requirements for additional reporting and the preparation of spill prevention plans will result in a total increased labor demand of one to two man years during 1979.

9.0 ELECTROMAGNETS

Large electromagnets are installed over conveyor belts to remove tramp iron from non-magnetic commodities such as coal and grain. Most of these electromagnets are cooled with 100 to 150 gallons of mineral oil. Where increased fire safety was required, the magnets were often filled with PCBs. The three magnet manufacturers who used PCBs were:

Sterns Magnetics, Cudahy, Wis.
Eriez Magnets, Erie, Pa.
Dings Co., Milwaukee, Wis.

Dings Co. stopped using PCBs in mid-1976; the other two manufacturers have not used PCBs since 1971 or 1972. A total of about 250 PCB magnets were manufactured; approximately 200 of these may still be in use in the United States. Most of the PCB magnets are being used in coal mines, coal preparation plants, and in coal-fired generating stations. It is possible, but not confirmed, that some of the PCB magnets may be used on grain conveyors because of the flammability of grain dust.

The electromagnets are of completely welded construction, and very few leakage incidents have occurred with either oil filled or PCB filled magnets. Based on design considerations, electromagnets would be expected to be less likely to fail than would transformers. Those leaks which have occurred have been caused by physical abuse or lack of adequate maintenance. Maintenance requirements do not expose workers or the environment to contact with PCBs.

9.1 Requirements of the Proposed Regulations

Only transformers and capacitors are defined as "totally enclosed uses" of PCBs. All other PCB equipment, including PCB electromagnets, must be removed from service by the effective date of the regulation, and disposed of in accordance with the "PCB Disposal and Marking" regulations.

Since incineration of the electromagnets is not feasible, each owner will be required to submit a written application to the Regional Administrator requesting permission to dispose of the units in a chemical waste landfill.

9.2 Compliance Costs

The PCB electromagnets could be replaced with oil filled units at an average cost of $8,000 per magnet. However, use of mineral oil in these applications would significantly increase fire risks. All of the manufacturers regularly furnish magnets filled with silicone fluid for use where fire characteristics superior to transformer oil are required. Such silicone filled transformers are 40 to 50% more expensive than oil filled units, i.e., $12,000 per average unit.

Eriez also offers a proprietary air cooled electromagnet which has Underwriters Laboratory approval for use in dirty and dusty environments. This unit costs about 30 percent more than an oil filled magnet, i.e., $10,400 per average unit.

Replacement costs for suitable magnets would be $10,400 to $12,000 x 200 units = $2,080,000 to $2,400,000. Delivery and installation costs would be an additional ten to twenty percent. As in the case of mining machines (chapter 8), the increased costs would be expected to be absorbed by the coal mines as reductions in profits. These costs should not result in any loss of employment or production.

Delivery of 200 replacement magnets would require four to six months.[1] Operation of the coal crushers without protection to remove tramp metal could result in a high risk of damage of the crushers with substantial losses in production. Radio frequency metal detectors can detect metal and shut down a conveyor belt until the metal is removed manually. These systems

(1) Consensus of industry opinion obtained through a phone survey by Versar Inc.

are expensive in terms of manpower and lost production compared to the use of separator magnets, but metal detectors could provide the temporary protection needed until replacement magnets were delivered. Detector systems which are presently in use are not manned continually, so it must be assumed that the lost production from belt stoppages is less expensive than manning would be. Assuming that a two-month delay would be experienced in obtaining replacement magnets, full time (3-shift operation) manning of the detectors at a burdened labor rate of $30,000 would cost (60 days x 24 hours per day x $30,000 per man year/1920 man hours per man year = $22,500 per magnet). Actual labor requirements might reasonably be 10% of this figure. This labor requirement would have to be added to the cost of a detector system. All of these additional costs are very dependent on the timing of the effective date of the regulation, and would be eliminated if the industry had six months notice of the intention of the Agency.

9.3 Summary

Cost Impacts:

Replacement cost - 200 electromagnets - $2,080,000 to 2,400,000

Delivery and installation costs - 200 electromagnets - $208,000 to 480,000

Labor cost increases due to short term lack of replacement magnets - $0 to $4,500,000 (probably $500,000)

Production and Price Impacts:

Costs are expected to be absorbed by the coal mining industry as a reduction in profits.

Employment Effects:

No loss of employment at the mines is anticipated. Assuming that one-third of the manufacturing and installation costs of the replacement units represents labor at $30,000 per man year, increased labor of

($2,288,000 to $2,380,000/ $30,000 per man year x 1/3 dollar labor per dollar cost = 25 to 32 man years) would be required in late 1978 and early 1979. Extra labor due to a lack of replacement units might increase employment by ($500,000/$30,000 per man year = 17 man years) during the first few months of 1979.

10.0 HYDRAULIC SYSTEMS

PCB fluids were used in a large number of hydraulic systems, particularly in die-casting machines and in steel industry applications where high-temperature stability and fire resistance were important considerations. In 1972, when PCB hydraulic fluids were no longer available, users were forced to switch to substitute fluids. Since the substitutes were compatible with the PCB fluids, the machines were not drained and flushed but were simply topped off as required with the new fluid. Topping off usually requires addition of new fluid at the rate of 2 to 10 times the system capacity per year to replace leakage losses.

Available data on residual PCB levels in die casting machine hydraulic systems indicate that many of the tested machines contained PCBs in concentrations of 60 ppm to as high as 50% in a few cases. The differences in concentration apparently reflect differences in the rate of leakage from various machines and differing company maintenance policies regarding periodic total replacement of hydraulic fluid.

10.1 Requirements of the Proposed Regulations

The proposed PCB ban regulations would prohibit the use of fluids which contain over 50 ppm PCBs in open or semi-closed systems. However, hydraulic systems on metal die casting machines which contain fluid with more than 50 ppm PCBs would be allowed to remain in service if they are drained, flushed with clean solvent, and refilled with uncontaminated hydraulic fluid. The fluid must be re-processed or replaced at intervals of six months to remove PCBs until the concentration of PCBs remains below 50 ppm. In addition, users of contaminated systems would have to report such use to EPA and petition annually for exemptions to continue using and periodically decontaminating the equipment.

The provision for continued use of these systems is limited to five years in the proposed regulation. However, it is anticipated that the required periodic decontamination of the systems will reduce the concentration of PCBs to below 50 ppm before the provision expires. Hydraulic systems on other types of machines would not be allowed to continue in service if the fluid contains more than 50 ppm PCBs. The machines would have to be removed from service by the effective date of the regulation and not used until the PCB level in the fluid is reduced to a concentration below 50 ppm.

10.2 Ownership and Use of Contaminated Hydraulic Systems

A previous EPA sponsored study reported that sales of PCB hydraulic fluid during the period 1970-1971 totaled over 13.5 million pounds to 585 different firms.[1] Except for a few companies with contaminated die casting systems which have been identified through statements at public hearings on PCBs, little information is available on the ownership of contaminated systems or the levels of PCBs in the fluid.

Based on statements made by several die casting companies and by a representative of the American Die Casting Institute,[2] PCBs were used as a premium priced alternative fluid in the hydraulic systems of die casting machines used to form aluminum, magnesium, and zinc castings. There are apparently few barriers to entry in this industry, and the constant entry of new die casting companies has provided a ready market for used machines.

A review of the Monsanto customer list reveals that about 80% of the 40 largest companies purchasing PCB hydraulic fluid in 1970 and 1971 were die casting companies.[1] Assuming that die casting companies purchased 80% of the fluid sold and used it in die casting machines, a total of (13.5

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(1) Versar Inc., Usage of PCBs in Open and Semi-closed Systems and the Resulting Losses of PCBs to the Environment, Unpublished Draft Report (EPA Contract No. 68-01-3259, Versar Report No. 474-5C), September 30, 1976, p. 13.

(2) Telephone conversation, Mr. Cornel (American Die Casting Institute, Inc.) with Robert Westin (Versar), April 25, 1978.

million lb x 0.8 / 11 lb per gallon = 1 million gallons) of PCB fluid was used in these machines during the two year period. Assuming further that each machine had a hydraulic system containing 500 gallons and required that amount each year to replace leakage, the total one million gallons of fluid could have been used by 1000 machines which used 1000 gallons each.

The remaining 20% of the largest purchasers of PCB hydraulic fluid were steel mills. PCB hydraulic fluid was reportedly used as a standard fluid in many plants in those applications where leakage would present a fire hazard. Representative uses would include steel furnaces, ladles, strip mills, vacuum degasers, and continuous casting machines. There is no information available on the total number of hydraulic systems in the steel industry that used PCB fluids, nor is there any information available as to the present concentration of PCBs in these systems.

10.3 Compliance Costs

Die Casting Machines

Most die casting machines were flushed and refilled with a non-PCB hydraulic fluid after the owners became aware of the environmental and health hazards associated with PCBs. The hydraulic fluid recommended by Monsanto as a replacement for the PCB fluid in 1971 was based on polychlorinated terphenyls (PCTs). The manufacturing of PCT fluid was discontinued in 1972 or 1973 and the product lines were replaced with other types of hydraulic liquids.

The refilled hydraulic systems have been maintained in use by topping off when necessary to replace leakage losses, and in some cases by periodic replacement of the fluid. As a result of the continual removal of contaminated fluid, the concentration of PCBs has been gradually reduced to low levels, although in many cases the residual PCBs exceed the 50 ppm limit proposed by the regulation. The available information on present levels of PCBs in the hydraulic systems of die casting machines is summarized in Table 10.3-1.

Table 10.3-1

Present PCB Levels in Die Casting Machine Hydraulic Systems

Company	PCB Level (ppm)
Cast Forge Co.[1]	80
Caterpillar Tractor[2]	below detection limit (systems are drained twice a year)
Outboard Marine[3]	90-6000 (currently average 500)

Outboard Marine Corporation owns approximately 130 die casting machines that at one time used PCB hydraulic fluid. These machines each contain an average of 500 gallons of fluid,[3] and are all contaminated with PCBs in concentrations above 50 ppm.

Several companies provided estimated costs for replacing hydraulic fluid, although not all of the figures were for the permitted draining and flushing procedure. Outboard Marine estimated a cost of $840,000 to drain their machines, flush them twice with mineral oil, and refill them with new hydraulic fluid. If hydraulic fluid were used as the flushing solution to avoid flammability problems the cost would be $1.2 million.[4]

General Motors stated that the cost of materials for replacing the fluid in their hydraulic systems would be as follows:[5]

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(1) Telephone conversation, Tom Grover (Cast Forge Co.) with Bruce Woodcock (Versar), September 22, 1977.

(2) Telephone conversation, Tom Berlett (Caterpillar Tractor) with Bruce Woodcock (Versar), September 22, 1977.

(3) Thomas, Hugh (Outboard Marine Corp.), Presentation at the EPA Informal Hearings on the PCB Ban Regulations, Washington, D.C., July 15, 1977 (p. 91 of transcript).

(4) Telephone conversation, Hugh Thomas (Outboard Marine Corp.) with Bruce Woodcock (Versar), September 23, 1977.

(5) Ward, William (General Motors Corporation), Presentation at the EPA Hearings on the PCB Ban Regulations, Chicago, Illinois, July 19, 1977, (p. 201 of transcript).

Item	Material Cost ($/gal of replaced fluid)
Solvent	$ 2.26
New Hydraulic Fluid	7.57
Disposal	0.57
Total	$ 9.40

Chevrolet estimated that it would cost $500,000 to replace the hydraulic fluid in the 25 systems (29,000 gal total capacity) in their Bay City (Mich.) plant.(1)

Representatives of two companies stated that if they were forced to use hexane or some similar solvent they would be severly affected as the seals in their machines would have to be replaced. Also, there was concern among those who have already flushed their machines that further flushing would not significantly lower the PCB level in their machines.

All of the available industry cost estimates are summarized in Table 10.3-2.

Table 10.3-2

Industry Estimates of the Cost of Draining, Flushing, and Refilling Die Casting Machine Hydraulic Systems

Company	No. of Machines	No. of Gallons	Total Cost $	$/Gallon	$/Machine
Chevrolet	25	29,000	500,000	17.24	20,000
General Motors				9.40*	
Outboard Marine	130	65,000	840,000	12.92	6,500

*Material cost only.

(1) Michigan Department of Natural Resources, File Memo, undated.

The industry cost estimates are roughly comparable to the cost estimate made by Versar and presented in Table 10.3-3. Since the Versar estimates do not include inventory costs or the cost of decontaminating the waste liquid truck, a figure of $14 per gallon might be a more realistic estimate of the average price of decontaminating hydraulic systems.

The effectiveness of the decontamination procedure will depend on how thoroughly the system can be drained of both the contaminated liquid and the flushing liquid and also on the amount of PCBs which are absorbed into gaskets and other porous material. Assuming that the draining and flushing procedure will remove 80% of the total PCBs, a system originally contaminated with PCBs at 1000 ppm will still be contaminated with 200 ppm six months after the first flushing, but the level of PCBs after the second flushing will never exceed 40 ppm. Since there will probably be considerable leakage and topping off between the flushings, the concentration of PCBs is likely to be even lower than these calculations indicate.

Assuming that each of the 1000 presently contaminated systems must be flushed and refilled twice, and that chemical analysis for PCBs is required six months after each flushing, the total costs involved will be:

First flushing 500 gal. @ $14/gal	$ 7,000
Chemical analysis	300
Second flushing	7,000
Chemical analysis	300
Total per machine	$14,600
Total for 1000 machines	$14,600,000

A major factor in the cost of decontaminating hydraulic systems is the cost of the uncontaminated fluid used to refill the systems. It is understood that both Outboard Marine and General Motors have conducted tests of methods to remove PCBs from hydraulic fluids. It is not known whether these methods involve distillation or adsorption. The feasibility of such processing may have a substantial effect on the costs of decontaminating hydraulic systems and on those companies which reclaim hydraulic fluid.

Table 10.3-3

Estimated Cost of Decontaminating Hydraulic Systems

	Cost per gallon	
	500 gallon system	2700 gallon system
New Hydraulic Fluid(1) (phosphate ester)	7.80	7.60
Flushing Fluid(1) - 1 gal/gal (low viscosity mineral oil without additives)	1.15	1.15
Transportation(2) (400 miles, includes flushing fluid)	.41	.41
Incineration - $.15/lb (includes flushing fluid)	2.85	2.85
Labor (2 man days per machine at $15 per burdened man hour)	.48	.09
Total	12.69	12.10

(1) Telephone conversation, John Colucci (E.F. Houghton) with Bruce Woodcock (Versar). April 27, 1978.

(2) Versar Inc., Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs, Springfield, Va.: National Technical Information Service (NTIS PB 267 833/2WP), April, 1977, p. 3-20.

Other Hydraulic Systems

Approximately 20% of the firms purchasing PCB hydraulic fluid in 1970 and 1971 were steel companies and other firms not engaged in die casting. It is therefore likely that 20% of the usage of PCB hydraulic fluid was in systems other than in die casting machines. Although there is little information available on the use of this material, apparently not all of the systems are still contaminated with significant concentrations of PCBs. Budd Co. stated that their operations should not be significantly affected by the proposed ban regulations since the hydraulic systems on each of their welders have been drained and refilled on the order of 120 times over the last five years.[1]

The procedure of draining, flushing, and refilling any of these other hydraulic systems to reduce the level of PCBs should cost approximately the same per gallon of fluid as a similar procedure performed on a die casting machine hydraulic system. As a rough estimate based on the proportion of PCB hydraulic fluid used in such systems, the cost of decontaminating these other hydraulic systems should cost 25% as much as the cost of decontaminating the die casting machines, or a total of $3,650,000.

The proposed regulations would require that the level of PCBs in these other hydraulic systems be reduced to less than 50 ppm by the effective date of the regulations or the systems removed from service until the required ~~decontamination is completed. This requirement may result in significant~~ additional costs due to disrupted production in steel mills, as the hydraulic systems are central to the operation of the large equipment used in these ~~facilities. However, there is not sufficient information available to establish whether the required decontamination can be accomplished by the effective date~~ of the regulation, nor to estimate what the costs due to production interrup- ~~tions would be.~~

(1) Telephone conversation, C.W. Habitz (Budd Co.) with Bruce Woodcock (Versar), September 22, 1977.

Reporting Requirements

The proposed regulations would require that owners of die casting machines having hydraulic systems contaminated with over 50 ppm PCBs report the identity of each contaminated machine and the concentration of PCBs in the fluid. This will require the identification of all machines that ever used PCB fluid and those that may have used PCB-contaminated reclaimed hydraulic fluid and the chemical analysis of the present fluid in these machines for the presence of PCBs. This sampling and analysis program may cover as many as 2500 machines and must be completed within 90 days of the effective date of the regulation.

Chemical analysis for the quantification of PCBs in hydraulic fluid would be considerably more complex and expensive than that required to determine the concentration of PCBs in 10-C transformer oil. This is because the presently used hydraulic fluids may be based on chemicals such as phosphate esters which require that the PCBs be extracted from the sample prior to analysis. The possible presence of PCTs in the fluid could interfere with the analysis for PCBs, and discrimination between these similar chemicals would require the use of a gas chromatograph/mass spectrometer rather than the simpler gas chromatograph usually used for PCB determinations. Versar estimates that the complete analysis of contaminated hydraulic fluid for PCBs may cost as much as $300 per sample on the average.

Review of the records to determine which machines may be contaminated with PCBs and the preparation of the report to EPA would be expected to require an average of three days for each of the 585 firms which purchased PCB hydraulic fluid in 1970 and 1971. This would result in a net employment demand of (585 companies x 3 days per company / 240 man-days per man year = 7.3 man years). At a burdened rate of $30,000 per man year, this would result in total reporting costs of (7.3 x $30,000 = $220,000).

Total costs attributable to the reporting requirement would be ($300 per sample x 2500 machines = $750,000) + $220,000 clerical = $970,000.

Spill Prevention and Control Plans

Each company which uses or services a die casting machine that is contaminated with PCBs will be required to develop and implement a formal spill prevention and control plan. Because of the complexity of the machines and the assumed requirement for periodic flushing and decontamination, the plan will be rather complex and may require the services of a registered professional engineer for one week at $250 per day. Preparation of these plans by all 585 affected companies could cost a total of (585 plans x 5 days x $250 per day = $730,000). This cost could be reduced by perhaps one half if a pro forma plan were developed under the sponsorship of a trade association or major manufacturer and made available to all affected firms.

Total expected cost of this part of the regulations would therefore be expected to be $365,000 to $730,000.

10.4 Summary

Identification of Contaminated Die Casting Machines

Analysis and Sampling	$ 750,000
Clerical - Report to EPA	220,000
Spill Prevention and Control Plans	$365,000 to $730,000
Decontamination of Die Casting Machines	14,600,000
Decontamination of Other Hydraulic Systems	3,650,000
Cost of Production Interruptions when other Hydraulic Systems Removed from Service	? (potentially large)
Total	$19,720,000

Employment Effects

Labor equals (.48/12.50 = 3.8%) of per gallon cost. Total labor cost = (.038 x 18,250,000 = $693,000). At $30,000 per man year, this is equal to 23.1 man years of labor, or 12 jobs for 2 years. Spill prevention plans would require 5 man years of effort. Reporting requirements would require an additional 7 man years.

Price Effects

The impact of these regulations may effect almost all die casting and steel companies. Increased costs would therefore be expected to be passed along to the consumers in higher product prices, although no individually significant price increases are expected.

11.0 HEAT TRANSFER SYSTEMS

PCBs have been extensively used as heat transfer liquids because of their excellent thermal stability and inherent fire safety. Although the heat transfer systems are usually quite tight, leakage can occur due to mechanical damage of the system or because fittings have loosened as a result of thermal cycling. The Yusho incident in Japan in 1968 caused the PCB poisoning of 1001 people due to the leakage of PCBs from a heat transfer system into rice oil that was being heated by the system.(1)

A previous EPA sponsored study estimated that total usage of PCBs in heat transfer systems in the United States has been over 21 million pounds.(2) Most of this material was manufactured by Monsanto and distributed under the trade name Therminol. Monsanto stopped producing PCB based heat transfer liquid in 1971 and advised its customers to drain and flush their systems before replacing the fluid with a non-PCB based liquid. An additional one million pounds of PCB heat transfer liquid was manufactured during the period 1971-1973 by Geneva Industries of Houston, Texas.(3) There was at least one company still using PCB based heat transfer liquid as late as 1976.(4)

11.1 Requirements of the Proposed Regulations

As of the effective date of the regulation, heat transfer systems containing a liquid contaminated with more than 50 ppm PCBs could not be used until the concentration of PCBs is reduced to less than 50 ppm.

(1) Kuratsune, Masanori, et. al., "Yusho, a poisoning caused by rice oil contaminated with polychlorinated biphenyls", RHSMHA Health Reports, Vol. 86, No. 12 (December, 1971), pp. 1083-1091.
(2) Versar Inc., Usage of PCBs in Open and Semi-closed Systems and the Resulting Losses of PCBs to the Environment, Unpublished Draft Report, (EPA Contract No. 68-01-3259, Versar Report No. 474-5C), September 30, 1976, p. 13.
(3) Ibid.
(4) Ibid, p. 26.

11.2 Ownership and Use of Contaminated Heat Transfer Systems

There is no data available on the total number of heat transfer systems which have used PCB based fluids in the past. However, a review of Monsanto's customer list for 1970 and 1971 indicated that 8.2 million pounds of PCB based heat transfer fluid was sold by Monsanto during those years to a total of 533 different firms.(1)

The present concentration of PCBs in the heat transfer fluid in any of the systems which previously used PCBs depends on how thoroughly each system was flushed when the PCB fluid was replaced and the amount of leakage and topping off that has occurred since then. Data on present PCB levels is available for only one system: a 14,000 gallon capacity PCB heat transfer system was drained and flushed in 1972 and refilled with a non-PCB fluid; the system has been in constant use since 1972 and presently contains fluid that is contaminated with two percent PCBs.(2)

Lacking any additional information, it must be assumed that most of the 533 companies which purchased PCB heat transfer fluid are still operating the systems and that most of these systems are contaminated with PCBs in excess of 50 ppm. It must further be assumed that the use of these systems is central to the manufacturing processes in which they are used, whether for drying, heating, or temperature control in exothermic processes.

11.3 Compliance Costs

It is not possible to estimate the total costs of decontaminating the existing heat transfer systems to comply with the requirements of the proposed regulation because neither the total number of systems nor their capacity is known. In principle, the costs of draining, flushing, and refilling the systems should be about the same per gallon for heat transfer systems as for hydraulic systems (see Section 10.3).

(1) Versar Inc., Usage of PCBs in Open and Semi-closed Systems and the Resulting Losses of PCBs to the Environment, Unpublished Draft Report, (EPA Contract No. 68-01-3259, Versar Report No. 474-5C), September 30, 1976, p. 9.

(2) Confidential information obtained from the user of the system by Versar during a telephone survey of major users of PCB heat transfer systems.

The disruption of industrial production caused by the requirement that contaminated heat transfer systems be removed from service immediately upon the effective date of the regulation may result in far larger costs than will the requirement to decontaminate the systems. Here again, the available information will not support even a guess at the magnitude of the economic impacts of the disruption on costs, production, and employment.

11.4 Summary

Over 500 heat transfer systems may be contaminated with PCBs in concentrations exceeding 50 ppm, but available data is not sufficient to support an analysis of the costs of decontaminating the systems or the economic impacts resulting from disruption of related industrial production.

12.0 COMPRESSORS

Turbinol 153, a PCB-based fluid, was tried as a turbine lubricant and working fluid in natural gas pipeline compressors by several companies during the late 1960s and early 1970s. Monsanto ceased producing this product in 1972, and the companies that were using it switched to alternate fluids at that time.

12.1 Requirements of the Proposed Regulations

The proposed regulation would prohibit the use of any systems which contain liquids contaminated with PCBs in concentrations exceeding 50 ppm after the effective date of the regulation.

12.2 Compliance Costs

Two purchasers of Turbinol 153, Columbia Gulf Transmission and Texas Eastern Transmission, were contacted by phone. Neither company had information available on the residual levels of PCBs in the turbine fluid, but both indicated that the systems were relatively tight, and there was seldom the requirement to top off the systems. Based on data available for hydraulic systems and heat transfer systems, it must be assumed that the compressor fluids are probably contaminated with PCBs in excess of 50 ppm.

There are perhaps ten gas pipeline compressor turbines in use that have their oil contaminated with PCBs. The proposed regulations would require that these turbines be removed from use until the concentration of PCBs is reduced to below 50 ppm. It is not known what costs would be involved nor the disruption to the delivery of natural gas that would result from removing these turbines from use. Assuming that the complexity of the turbines is similar to that of the hydraulic systems discussed in Chapter 10, a cost of perhaps $20,000 and $40,000 per machine may be involved in the decontamination of the oil systems. Total costs might be several hundred thousand dollars plus the cost of disruption of the gas delivery system.

The cost of shipping gas by pipeline is established by long term contracts. Additional costs resulting from the provisions of the draft regulations would have to be absorbed by the pipeline companies.

12.3 Summary

Decontamination Costs ~ $200,000.

13.0 RECLAIMED OIL

Approximately 1.3 billion gallons per year of used oil is collected for use as road oil, fuel oil, re-refined hydraulic oil, and re-refined lubricating oil. Much of the waste oil previously used in applications other than automotive lubrication has been contaminated with low levels of PCBs, and dissipative uses of this contaminated oil can introduce PCBs directly into the environment.

A total of 2,376 million gallons of new oil were sold during 1975, the major commercial uses being automotive lubrication (50.8 percent); industrial and aviation lubrication (30.5 percent); and other industrial uses primarily in materials processing (17.4 percent). The amount available for collection and recycle was estimated to be 1,154 million gallons, or 48.6 percent of total sales. Data on U.S. usage of new (virgin) refined oil and availability of used oil for recycling are presented for the year 1975 in Table 13.0-1.[1]

Data generated by Recon Systems[2] for a 12-month period during 1970-71 indicate that, out of a total U.S. production of 2,480 million gallons per year, approximately 901 million gallons, or about 36.3 percent, were actually collected for recycling or use as fuel. An additional 601 million gallons were estimated to be used on roads (application for dust control and possibly in asphalt) or as fuel oil; this used oil could conceivably have been collected for recycle so that the maximum amount of oil available for collection, based on the Recon Systems estimates for 1970-71, may be as much as 60 percent of that produced.

A flow chart showing the distribution and utilization of waste oil in the United States, based on the 1970-71 data of Recon Systems, is presented on Figure 13.0-1. Summary data for disposition and usage from Figure 13.0-1 are as follows:

(1) Adapted from Table 1, page 24 of Assessment of Industrial Hazardous Waste Management Practices, a document prepared for EPA's Office of Solid Waste and presented with testimony of H. Lanier Hickman, December 12, 1977.

(2) Weinstein, Norman J., (Recon Systems, Inc.), Waste Oil Recycling and Disposal, EPA-670/2-74-052, Princeton, N.J.: August, 1974.

Table 13.0-1

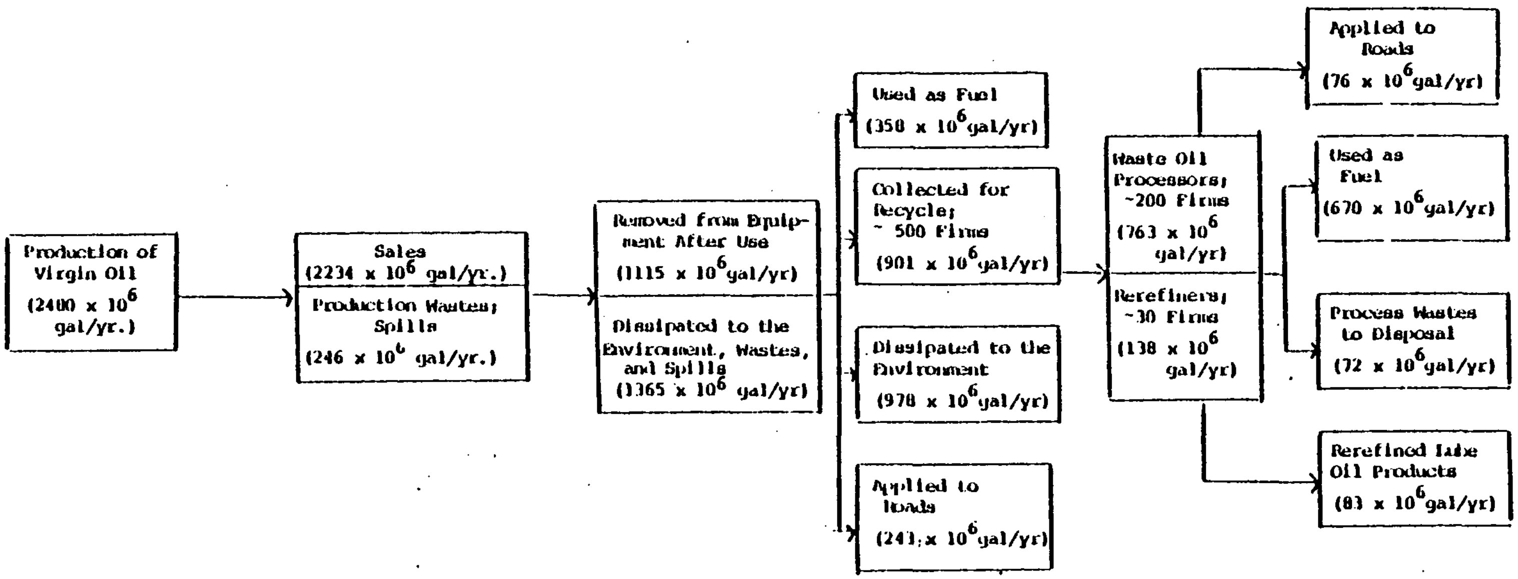
New Oil Usage and Waste Oil Availability for Recycling in 1975[1]

Type of Oil	Outlet or Use	U.S. Sales 1975 (gal x 10^{-6})	Fraction Available* for Recycle	Used Oil Available for Recycling
Automotive Lube Oil	Service Stations	239	.63	150
	Commercial engine fleets	225	.50	112
	New car dealers	103	.90	93
	Auto fleet and other lube oil uses	151	.50	75
	Retail sales for commercial engines	95	.63	60
	Garages, auto supply stores	90	.63	57
	Discount stores	250	.22	55
	Factory fills (auto & farm equipment)	54	.90	49
	Subtotals	1,207		651
Industrial & Aviation Lube Oils	Hydraulic & circulating system oils	314	.42	132
	Metal working oils	145	.70	101
	Aviation & other	147	.50	73
	Gas engine oils	60	.90	54
	Railroad engine oils	58	.53	31
	Subtotals	724		391
Other Industrial Oils	Electrical oils	62	.90	56
	Process oils	340	.10	34
	Refrigeration oils	11	.50	5
	Subtotals	413		96
Lube Oils Purchased by U.S. Government		32	.50	16
	GRAND TOTALS	2,376		1,154

*Fraction available for recycling after losses in use and to environment.

(1) Weinstein, Norman J., (Recon Systems, Inc.), Waste Oil Recycling and Disposal, EPA-670/2-74-052, Princeton, N.J.: August, 1974.

Figure 13.0-1. Distribution and Utilization of Waste Oil in the United States During 1970-71



Source: Adapted from Table 26, p. 128 of Weinstein, Norman J., (Recon Systems, Inc.), Waste Oil Recycling and Disposal, EPA-670/2-74-052, Princeton, N.J.: August, 1974.

Fate of Oil After Primary Use	Percentage of New Oil Production
Used as fuel	41.5
Dissipated to environment and waste disposal	42.3
Applied to roads	12.9
Re-refined lube oil products	3.3
	100.0

The general distribution portrayed in Figure 13.0-1 is believed to be valid at present, although the magnitudes of the specific flows have fluctuated as prices of virgin lube oil and fuel oil have varied. The value of fuel oil has increased since 1970-71, and virgin lube oil was scarce during the period of the Arab boycott and during a portion of the period of price controls. One result of these factors has been increased use of waste oil as fuel, either internally by industrial concerns which generate waste oil or via processors.

The primary sources of waste oil available to collectors are service stations and other automotive-related facilities. Industrial and avaiation facilities are also significant sources. A significantly larger fraction of available oil is collected in urban areas than in suburban or rural areas. Based on studies in the Pittsburgh area, spills and other wastes from product pipelines are a locally significant source of waste oil for collection.

The use pattern of processed or rerefined waste oil is extremely diffuse. Users include states and municipalities (road application), industrial and commercial facilities (fuel, re-refined lube oils, road oil), utilities (fuel), and the consuming public (re-refined motor oil).

A small portion of the collection and processing of used hydraulic oils does not follow the general pattern of scattered sources, many reclaimers, and numerous users indicated for the waste lube oils. Reclamation of used hydraulic oil, performed in most part by four companies, results in a product which is marketed as hydraulic oil.

13.1 Requirements of the Proposed Regulations

The disposal of oil contaminated with PCBs in excess of 500 ppm is regulated by the 'PCB Marking and Disposal Regulations'. The proposed 'PCB Ban Regulations' would change the definition of 'PCB Mixture' used in the Marking and Disposal Regulations to include all mixtures containing more than 50 ppm PCBs. This will affect the allowable uses and disposal of oil contaminated with lower concentrations of PCBs.

Under the provisions of the proposed ban regulations, oil contaminated with PCBs in excess of 50 ppm would have to be identified, segregated for purposes of disposal, and burned in an approved chemical waste incinerator. Oil containing measurable amounts of PCBs less than 50 ppm could be processed for any use including as fuel or reclaimed lubricating or hydraulic oil, but could not be used as road oil or as a constituent of any sealant, coating, or dust control agent.

13.2 Sources and Amounts of Contaminated Waste Oil

Hydraulic Fluids Oil is used as a low viscosity fluid in hydraulic systems, and PCB based hydraulic fluids were widely used prior to 1972. The most expensive (and polluting) use was in die casting machinery. PCB based hydraulic fluids were also used in construction machinery, farm machinery (a source of feed contamination)[1] and in deep mining equipment where the use of PCBs resulted in greater fire safety.

Although hydraulic systems are nominally air-tight, leaks may occur at dynamic seals and major spills may occur due to hose rupture. Normal leakage is collected in drip pans. The rupture of a hose can spray hydraulic fluid over a large area due to high operating pressures. It has been estimated that 80% of phosphate ester hydraulic fluid losses occur due to leakages in the hydraulic system.[2] In certain industries, operators state that it is more efficient to continually add hydraulic fluids to the system rather than shut the system down, repair any leaks, and refill the system. Leakage from these systems is often collected and reclaimed.

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

(2) Lapp, T.W. (Midwest Research Institute), The Manufacture and Use of Selected Aryl and Alkyl Aryl Phosphate Esters, EPA 560/6-76-008, Feb. 1976, p. 77.

Monsanto manufactured almost all the PCB-based hydraulic fluids. When Monsanto discontinued manufacturing PCB-based hydraulic fluids in 1971, they did not recommend draining or flushing of hydraulic systems but that replacement fluids should be added to the remaining PCB fluids in the system. As a result, hydraulic systems which used PCBs in 1972 and prior years now contain replacement fluids contaminated with .006 to 50% PCBs as discussed in Chapter 10. The total amount of contamination is a function of the system leakage and dilution during the past five years.

A portion of the available used industrial hydraulic oil is refined and sold for reuse as hydraulic oil. This specialized reclaiming service is furnished by the following four companies which reclaim a total of about 150,000 gallons of hydraulic fluid per year.

E. F. Houghton and Co., Philadelphia, Pennsylvania
Radco Corporation, LaFox, Illinois
Findett, Inc., St. Charles, Missouri
Wallover Corp., East Liverpool, Ohio

Automobile and Industrial Lubricating Oil The amount of used oil collected for reuse in 1970-71 was about 900 million gallons per year, with an additional 600 million gallons used internally for fuel or dust control on roads.(1) Thus, about 60 percent of the amount of new oil sold was reused. Major uses of this oil were as fuel (1028 million gallons), road oil (319 million gallons), and feedstock for re-refined lubricating oil (138 million gallons).

The extent of PCB contamination of this oil was studied on a limited basis by the EPA National Enforcement Investigation Center (NEIC) in Denver.(2) Samples of oil were taken from selected tank truck lots of used oil that had been collected in Virginia, Maryland, and North Carolina. This oil had been delivered to Continental Forest Industries in Hopewell, Virginia,

(1) Weinstein, N.J. (Recon Systems, Inc.), Waste Oil Recycling and Disposal, EPA-670/2-74-052, Princeton, N.J.: August, 1974.

(2) Magruder, Robert S. (Continental Forest Industries), testimony presented at the US EPA informal hearings on the PCB ban regulations, Washington, D.C., July 15, 1977.

for use as supplemental fuel in a steam boiler of a paper mill. The oil had been collected primarily from automobile service stations, although it is possible that some industrial oil, including hydraulic oil, had been included in some of the lots. PCBs were found in the samples of oil at concentrations ranging from 3.2 ppm to 19.4 ppm. Although these oil samples were collected from a restricted area, the extent of PCB contamination is probably representative of waste oil collected throughout the United States.

The PCB contamination of the waste oil could come from contaminated industrial hydraulic oil or transformer oil or from PCB additives used in lubricating oils prior to 1973. In applications such as railroad car journal box oils, PCBs may have been used as lubricant additives.[1] PCBs may also have been added to automobile transmission fluids to control the swelling of oil seals.

It would not be expected that PCBs would be destroyed during re-refining of waste oils. PCBs were reported to be present in concentrations of several parts per million in reclaimed oil used to lubricate whetstones.[2]

13.3 Compliance Costs

Collection of any waste oil likely to be contaminated with PCBs for a controlled use would not be attractive financially unless the oil were known to contain PCBs at levels below the control amount. Analytical costs for determining low levels of PCBs will be considerably higher than the costs quoted for transformer oil because naturally occurring sulfur and chlorine compounds in petroleum oils cause interferences in the use of electron capture gas chromatography at concentrations of 5 ppm PCBs or below.[3] These

(1) Monsanto Chemical Company, Aroclors for ---, St. Louis, Mo.: undated.

(2) Weems, George, (United States Department of Interior, Denver, Colorado), "Polychlorinated Biphenyls", File HLS 3-3-10h, June 13, 1977.

(3) Hofstader, R.A. (Exxon Research and Engineering Co.); Lisk, D.J., Bache, C.A. (Cornell University), "Interference in the Electron-Capture Technique for Determination of Polychlorinated Biphenyls by Sulfur-Containing Compounds in Petroleum Products", Bulletin of Environmental Contamination and Toxicology, Vol. 11, No. 2, 1974.

interferences result in false positive indications of the presence of PCBs. The PCB components can only be resolved through complex clean-up procedures or the use of gas chromatography/mass spectrometry, techniques that would cost up to several hundred dollars per sample.

Road Oiling

The most recent data indicates that road oiling consumes 319 million gallons of waste oil per year (Figure 13.0-1). At an application rate of 1/2 gallon per square yard, this is sufficient to oil 45,000 miles of roadway 24 feet wide. The proposed ban regulations would forbid the use of oil containing detectable amounts of PCBs for dust control. Fluids from transformers are likely to have detectable amounts and other industrial sources are at least somewhat suspect. Currently these industrial oils are collected along with used motor oil. Although virgin motor oil has no PCBs, used motor oil may have PCBs from previous recycling which included industrial oil sources among the feedstocks or from old transmission oils which contained PCBs as an additive. Nevertheless, used motor oil unmixed with industrial sources is unlikely to contain as much as 10 ppm PCBs, and may have PCB concentrations that are undetectable without unusually elaborate and expensive analysis. None of the reported analyses of waste oil for PCBs was based on used motor oil without any possibility of industrial contamination. Presumably waste oil solely from automotive sources would contain fewer PCBs. It is doubtful that road oiling could stand the costs of even "simple" tests at $70 per sample. Prospective road oilers therefore would be safer using waste oil if they take precautions to ensure that it does not contain industrial oils (and certainly no electrical oils).

Compliance with the requirements of the proposed regulations could be achieved by either of the following strategies:

(1) Avoid all waste oil and substitute virgin oil at considerable monetary and energy cost where the customer is willing to pay the increased price. At an average price of $.375 per gallon for #2 fuel oil vs $.08 per gallon collection costs for used crank case oil, the cost of road oiling would increase (.375 - .08) x 139 million gallons = $94 million per year.

(2) Use synthetic road stabilization chemicals which both reduce dust and provide surface stabilization. The increased cost of this type of material is presently offset by lower road maintenance costs on heavily traveled dirt roads at mines and other industrial facilities. Savings in maintenance on lightly traveled roads would be less significant and would only partially offset the increased material costs. A typical synthetic material is "Coherex", manufactured by Witco Chemical Co. This material is an organic resin in a water emulsion which is sold for $1.25/gallon, and applied after a 5 to 1 water dilution at a rate of one gallon per square yard. Increased costs incurred by the use of this material would be:

	Coherex: 1/6 gallon per square yard @ 1.25	= .208
minus:	Used Oil: 1/2 gallon per square yard @ .08	= .04
equals:	increased material cost per square yard	.168
	x 14080 sq. yds. per mile of road 24 feet wide	= $2365 per mile
	x 45,000 miles	= $106 million per year.

These increased costs will be incurred until the concentration of PCBs in used motor oil drops below detectable levels. In perhaps five years, it may be possible to use waste motor oil for road oiling with little chance of releasing PCBs to the environment, provided that care is taken to avoid using waste industrial oil. The diverted industrial oil can be made up at modest added costs by more extensive collection efforts particularly in rural areas. The costs of obtaining this replacement motor oil for road oiling consists of costs to persuade service stations to accept used oil from persons who change oil themselves, and perhaps either greater storage capacity at stations or more frequent collections. Alternatively, collectors could travel further in rural areas and thus visit more service stations not now part of the recycling systems. These extra costs will not be incurred unless road oilers will accept necessary price increases to cover these costs. Total costs might reasonably be expected to increase .02 per gallon ($6.4 million per year) plus the risk of inadvertently using contaminated oil in occasional instances. After an additional ten years, it may no longer be necessary to segregate the industrial oil, and costs would return to their present levels.

Users Other than Road Oilers

About 27 million gallons per year of transformer oil will not be available to collectors, thus initially reducing the total supply. Other industrial oils may or may not be contaminated with PCBs; to be absolutely safe, the recycling industry would avoid them. Individual industrial firms can probably continue to use their own waste oil as fuel oil if they make initial and occasional later spot check laboratory analyses to make sure their oils continue to contain less than 50 ppm PCBs.

The impact on re-refiners (who make re-refined lube oil) and external processors (who process waste oil for use as fuel oil) will depend on what happens to road oiling. A strict enforcement policy with occasional all-out efforts to find PCBs in waste oil could prevent its use as road oil. Diversion of waste oil from this use would create a large increase in supply for processors and re-refiners. Probably most of this would originally go to fuel oil use since the capacity of re-refiners is limited and the consumer acceptance of used motor oil is limited. Later, a majority of the increase might go to re-refiners if the Frost and Sullivan market projections of 23 percent growth per year until 1985 proves to be even roughly accurate.[(1)] This would provide an extra use as lube oil while retaining most of the heat value for later use.

Collectors

If collectors avoid transformer and industrial oils, their total business will decrease. However, haulage of the contaminated oils to chemical waste incinerators will be required and could offer new market opportunities to the collectors.

Processors

Waste oil for fuel use should become more plentiful as use for road oiling is discouraged or made impossible by the regulation. The effect of a larger supply of waste oil on the price to processors theoretically would

(1) Maugh, T.W., "Rerefined Oil: An Option That Saves Oil, Minimizes Pollution", Science 193, p. 1108-1110, September 17, 1976.

be to lower the price. However, since use on coal in boilers is relatively troublefree and expandible, this use is probably very eleastic. Consequently if coal burning plants can absorb the increased supply, which seems likely, the price decrease should be negligible.

Re-refiners

Re-refiners of lubricating oils should be operated at capacity and thus be more profitable. The recycling ethic potentially can be used to expand the market for used lube oil faster than industry capacity. This will be especially true for industrial and commercial fleets, but might be extended to personal cars. Similarly, increases in domestic crude oil prices would increase the market for all uses of waste oil.

Information collected through telephone interviews indicates that at least three of the companies which re-refine hydraulic fluid receive hydraulic fluids which are contaminated with PCBs. These fluids are sometimes contaminated to the extent of 6000 ppm. In most cases, the reclaiming process removes no more than 10% of these PCBs.[1] It is also reported that the concentration of PCBs in some of the hydraulic fluid applications encountered by these companies remains at approximately 2000 ppm despite repeated flushings and drainings. In such cases, lower PCB levels may be achievable through the use of activated carbon filtration.

Those hydraulic systems contaminated with PCBs will be identified as required by other provisions of the draft regulations. Once this is done, waste oil from these machines and from the oil separators in plants using the machines will probably have to be diverted from fuel use to chemical waste incinerators.

The price differential between re-refined and virgin hydraulic fluid is about four dollars per gallon. The requirement that contaminated hydraulic oil be incinerated may reduce the supply of re-refined oil from 150,000 gallons per year to 50,000 gallons per year. This would result in increased costs of ($4.00 per gallon x 100,000 gallons per year = $400,000

(1) Telephone conversation, Dwain Fowkes (RADCO Corp.) with L. Fourt (Versar), September 19, 1977.

per year), and could force the closing of three small firms with a total ployment of 12 to 15 persons.

Industrial Waste Oil Generators

Those industries whose waste oil contains more than 50 ppm PCBs will have to incur disposal costs of $.0832/lb. Even industrial oil contaminated with less than 50 ppm PCBs may be avoided by waste oil collectors. This will not be a big problem for coal burners. Fuel oil burning companies can use a mixture of waste and virgin oil but there are technical problems to be mastered in this use. Continental Forest Industries indicated that up to 14 percent waste oil mixed with #6 residual oil is feasible. The result may be the development of a separate market for industrial oil with low levels of PCBs for use as fuel. Long term economic impacts should not be significant.

13.4 Summary

Compliance Costs

Road Oil - increased costs of virgin or synthetic material (years 1-5)	$100 million/year
Road Oil - increased cost of obtaining adequate supplies of segregated used motor oil (years 6-15)	$6.4 million/year
Lost production of re-refined hydraulic fluid	$ .4 million/year

Employment Effects

Three small re-refiners may close with a loss of 12 to 15 jobs. Shifts will occur in the collection segment of the industry, but will probably have little net impact on employment.

14.0 PCBS AS UNINTENTIONAL PRODUCT CONTAMINANTS

Although most of the PCBs in use were produced by Monsanto as the primary product of a reaction process, other chemical reactions can produce PCBs as by-products, resulting in contamination of commercial chemicals. Similarly, contamination of existing material may result in PCB contamination of products made by recycling these materials. Recycled paper is known to be contaminated with PCBs at low levels, but a detailed study of this industry indicated that it would not be affected by the 50 ppm limit on PCB contamination.(1) Polychlorinated terphenyls have also been reported to be contaminated with PCBs formed as a side reaction during manufacturing,(2) but the sole U.S. distributor of this material has reportedly assured its major customer that it would warrant that future shipments will contain less than 50 ppm PCB.(3)

The only chemicals known to be contaminated with PCBs in concentrations exceeding 50 ppm are certain phthalocyanine blue and green pigments and the diarylide yellow pigments.

14.1 Requirements of the Proposed Regulations

The regulations ban the continued manufacture of PCBs after December 31, 1978. This ban also applies to mixtures containing more than 50 ppm PCBs regardless of whether the PCBs were added intentionally or formed during manufacture as an unintentional by products.

14.2 Compliance Costs

Phthalocyanine Pigments

Phthalocyanine pigments are major sources of heat- and light-stable blue and green colors in the plastics and printing inks industries. In the manufacture of copper phthalocyanine blue pigment (phthalo blue), the

(1) Versar Inc., Involvement of PCBs in the Pulp and Paper Industry, EPA 560/6-77-005, February 25, 1977.
(2) Versar Inc., Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs, EPA 560/6-77-007, February 22, 1977.
(3) Personal communication, L.M. Argueso (M. Arguaso and Co., Mamaroneck, N.Y.), August 30, 1977.

copper used in the reaction apparently catalyzes the dehydrochlorination of the trichlorobenzene (TCB) solvent used in the process to form varying amounts of trichloro and pentachloro biphenyl residue in the product. Further chlorination of phthalo blue to make phthalo green pigment results in the formation of PCBs residues in the green product. Domestic and foreign manufacturers of phthalo pigments, using the TCB solvent process, have tested these pigments for PCBs level. Results indicate that this process consistently produces pigments with PCBs residues in the 100-300 ppm range. One analysis from a domestic manufacturer reported concentrations as high as 1000-2000 ppm. Several U.S. companies manufacture the phthalo pigments from the basic raw materials, while the other U.S. companies marketing these pigments import foreign TCB-based crude pigments and purify them for sale in the United States. Under the proposed PCB ban regulations, all of these manufacturers are in effect producing a PCB mixture which could not be sold or distributed in commerce effective 30 days after promulgation of the draft regulations.

Discussions with the domestic phthalo pigment manufacturers have disclosed that only one manufacturer does not use the TCB solvent process (kerosene is used as the solvent in a proprietary process and the pigment produced has essentially zero PCBs). All other domestic and foreign manufacturers use TCB solvent, and are accordingly faced with major process revisions to comply with the proposed 50 ppm PCBs limit in their product.

The concentration of PCBs in the phthalocyanine blue and green pigments can reportedly be reduced to below 50 ppm by a change in the solvent used in the manufacturing process. Such a change will require modifications of the process and quality control procedures, and may cost $100,000 for each of the five or so manufacturers and importers of the material. Since uncontaminated pigment is available from one U.S. manufacturer, there is sufficient price competition to prevent these increased costs from being passed along in higher product prices. The effect would therefore be a decrease in corporate profits.

Diarylide Yellow Pigments

Diarylide pigments are the major yellow pigments used in printing inks. These pigments are made by reactions of precursors which include dichlorobenzidine. A minor side reaction results in the deamination of the benzidene resulting in the formation of 3,3'dichlorobiphenyl. According to Don Morgan of the Dry Color Manufacturers Association,[1] most diarylide yellow pigments are contaminated with PCBs at concentrations of several hundred parts per million. Although a few batches of pigment have been found to contain less than 50 ppm PCBs, the industry is not yet able to control the manufacturing process to reliably achieve this low level of PCB contamination.

Sales of diarylide yellow pigment in 1976 were about 12.66 million pounds having a value in excess of $52 million.[1] This pigment was contaminated with perhaps several thousand pounds of 3,3'dichlorobiphenyl, which is a relatively biodegradible isomer of PCB. If the proposed PCB ban regulations result in an effective ban on the manufacture of this yellow dye, most colored printing inks will have to be reformulated, resulting in some lost production while technical changes are made in the $690 million/year ink industry and the $43 billion per year graphic arts industry.

There is no technology available that can reliably reduce the concentration of PCBs in diarylide yellow pigments to below 50 ppm. If the ban on the manufacture of PCBs after December 31, 1978, results in an effective ban on the manufacture of this pigment, lost sales of this material will be about $52 million per year. Alternative pigments are available, but their use results in higher ink costs as the alternative materials are less effective and/or more expensive. Increased costs due to the conversion to substitute materials may equal 20 percent to 50 percent of the value of the discontinued yellow pigments, or $10 million to $25 million per year. There should be no net employment effects as the production of substitute materials will offset the losses from the discontinuation of manufacture of the diarylide yellow. However, several hundred jobs may be affected at the impacted manufacturing facilities, and an unknown amount of production equipment would lose economic value.

(1) Telephone conversation, Don Morgan (Attorney for the Dry Color Manufacturers Association) with R. Westin (Versar), September 22, 1977.

14.3 Summary

Compliance Costs

Phthalocyanine Blue -	Production changes	$500,000 - 1978
Diarylide Yellow -	Increased costs of substitute pigments	$10 million to $25 million per year

Employment Effects

Several hundred jobs would be affected if the manufacture of diarylide yellow pigments were banned. These would be offset by employment increases in the segments of the pigment industry supplying the substitute materials.

15.0 CAPACITOR MANUFACTURING

The use of PCBs in the manufacture of new capacitors is expected to end by mid 1978 due to a number of factors including the ending of production of PCBs by Monsanto in October, 1977 and the zero PCB discharge requirements imposed on the manufacturing plants by the EPA under authority of the Federal Water Pollution Control Act.[1] However, the decision of the capacitor manufacturers to discontinue the use of PCBs without attempting to develop alternate sources of supply after Monsanto stopped production was made in anticipation of the implementation of the Ban Regulations of Section 6(e) of the Toxic Substances Control Act. Although the EPA apparently has no discretion in the implementing the ban on the use of PCBs in the manufacture of capacitors, the economic impact of the change to alternate materials and designs is undoubtedly the result of the provisions of the Act as implemented by the proposed regulations.

15.1 Requirements of the Proposed Regulations

The proposed regulations would ban the manufacture of capacitors containing PCBs after December 31, 1978 as the EPA has determined that the ban in Toxic Substances Control Act on the manufacture of PCBs applied also to the manufacture of items which are considered to be "PCB Articles" or "PCB Equipment."

15.2 Capacitor Production and Sales

PCBs have been used as a dielectric liquid in most of the alternating current capacitors manufactured since 1930. PCBs provided the advantage of non-flammability which is not available with electrically suitable alternative liquids. The development and commercial introduction of non-PCB capacitors started in 1975 in response to growing concern over the environmental effects of PCBs. The time required to develop various types of non-PCB capacitors

(1) EPA, "Final Decision," Federal Register, February 2, 1977, pp. 6531-6555.

has been a function of the fire hazard which would result from the failure of each type of capacitor. Segmentation of this industry by type of capacitor is required to calculate the impacts of the draft regulations.

PCB capacitors have been made in many different sizes and in designs suitable for many different voltages and applications. For the purpose of this analysis, all of the various types of PCB capacitors will be classified as either power factor capacitors or industrial capacitors. Power factor capacitors are those large high voltage units used by utilities to correct for lagging power factor in electric transmission and distribution systems. Industrial capacitors include all other types of PCB units which are used in association with specific types of equipment such as electric motors, fluorescent light ballasts, and electronic circuitry.

Census figures for capacitors are collected by the U.S. Department of Commerce on the basis of seven digit SIC codes. The most recent data at this level of disaggregation was obtained in 1972 and is summarized in Table 15.2-1 below. More information at this level will be obtained in 1978, but will not be available for several years.

Table 15.2-1

PCB Capacitor Production and Sales: 1972[1]

Type	Production-Units	Sales-Million $
Shunt and Series Power Factor Correction	192,700	41.1
General Purpose Motor Control	22,100,000	39
Fluorescent Light Ballast Capacitors and other capacitors except electronic	not available	32.3

(1) Source: U.S. Department of Commerce, Electrical Measurement and Distribution Equipment, Publication MC(2-36A).

Annual estimates of capacitor sales volume are available on an aggregate basis from a 20% survey of manufacturers at the five digit SIC code level. The recent information available from this source is summarized in Table 15.2-2.

Table 15.2-2 (1)

PCB Capacitor Sales - by Year

Year	Sales - Million Dollars
1972	112.4
1973	143.1
1974	157.3
1975	119.3
1976	149.0

(1) Source: U.S. Department of Commerce

15.3 Compliance Costs

There are two basic technological alternatives available to capacitor manufacturers who must develop non-PCB capacitor product lines. The direct, and probably short term, solution to the problem is to develop a dielectric liquid which can be used as a direct replacement for PCBs within the presently used technology of capacitor production involving aluminum foil and paper as a solid dielectric. This type of construction has been developed to maximize the advantages achievable using PCBs as a liquid dielectric. An alternative approach would be to develop a new technology which makes optimum use of the materials remaining available to product designers.

Much effort has been spent in evaluating materials for use as PCB substitutes in both the U.S. and in foreign countries. No substitute liquid has been developed which equals PCB in dielectric properties, fire resistance, and stability. Any trade-off entails enhancing electrical performance at the expense of environmental or safety considerations. Impregnating capacitors with alternative dielectric fluids and/or redesigning them may result in substantial retooling, research and development, and other production-related costs. Such costs are normally high at first, since the industry is essentially characterized as infant; i.e., it is facing a new learning curve due to the production of technologically new capacitors. However, since all manufacturers are developing non-PCB capacitors, and since these new products will be introduced essentially simultaneously, there will be substantial competition which will prevent the rapid recovery of development and tooling costs through market skimming. Therefore, it is expected that the initial product prices will closely approximate the long term competitive price structure of the capacitor industry. A review of the present status of each of the major segments of the capacitor industry should provide an accurate picture of the response of this industry to the PCB ban regulations.

Power Factor Capacitors

Large power factor correction capacitors which operate at voltages above 2000 volts are used by electric utilities to compensate for inductive-current lags caused by inductive motors and other similar machinery. These capacitors are usually mounted out of doors in substations or on power poles, and little risk of significant fire losses is incurred by the use of a flammable dielectric liquid in these units.

Prior to 1977, there were four manufacturers of PCB power factor capacitors. All four of these manufacturers discontinued the use of PCBs during 1977 and introduced non-PCB capacitors having the same functional specifications as replacement products. Table 15.3-1 lists the manufacturers of these large capacitors and summarizes the technology used in the new products introduced by each manufacturer. The selling prices of these large capacitors are negotiated on the basis of large orders, and no published price lists are available. However, Versar estimates that the prices of the capacitors manufactured by Westinghouse, General Electric, and Sangamo increased 10% to 15% following the introduction of non-PCB units, and the price of the McGraw Edison capacitors increased 15% to 20%. McGraw Edison claims exceptional product life and efficiency for their product, and the higher price has apparently not had a significant impact on their share of the market.

Sales of PCB power factor correction capacitors in 1976 are estimated to have been approximately $54.5 million. Assuming relatively constant output and demand, a ten to twenty percent price increase of comparable non-PCB power factor correction capacitors will result in sales of approximately $60.0 to $65.4 million (using constant dollars). Hence, utilities and other users of power factor capacitors are expected to pay approximately $5.5 to $10.9 million more.

Utilities employ approximately ninety-five percent of all power factor correction capacitors. The ability of utilities to pass all of the additional costs associated with non-PCB capacitors on to residential and commercial users in terms of higher prices will depend upon state regulatory commissions' attitudes toward rate structures. Total revenue for all electric utilities was $46.2 billion in 1975. It is estimated that total revenue for all utilities in 1976 will have been approximately $50.0 billion. If all the utilities additional costs associated with using non-PCB capacitors is passed on to residential consumers, and that their average monthly electric bill is fifty dollars, it is estimated that residential consumers will incur an increase in their electric bills of approximately .02 percent, or one cent per month. [Note that this is the long run effect; in the short run the extra costs of non-PCB capacitors will appear as a capital item in the rate base. If depreciation and replacement are both straight-line functions, over a ten year period, the rate base and the return on it will rise until the tenth year at which point a small return on capital will be obtained as well as capital replacement costs.] Since part of the costs will be passed on to industrial users, the relative price impacts will be even less, and are not expected to significantly impact either the price or demand for electricity.

Table 15.3-1

Currently Available Non-PCB Power Factor Correction Capacitors

Manufacturer	Solid Dielectric	Liquid Dielectric*
Westinghouse	Paper and plastic film combination	Isopropyl biphenyl
General Electric	Paper	Phthalate ester**
Sangamo Electric Co.	Paper	Phthalate ester**
McGraw Edison	Plastic film	Butylated monochlorodiphenyl ether

* All of the liquid dielectric materials contain small amounts of additives as free radical scavengers, etc. The identity of these minor constituents is proprietary information.

** The phthalate ester based liquids reportedly contain a significant amount of trichlorobenzene as an additive to raise the corona extinction voltage.

Industrial Capacitors

PCB capacitors have been used in a number of diverse industrial, appliance, and lighting applications including arc welders, induction heating furnaces, fluorescent light ballasts, and television sets. Table 15.3-2 lists the manufacturing plants known to have used PCBs in the manufacture of this type of capacitor in the early 1970s. Versar contacted these manufacturers in September, 1977 to determine whether they were still using PCBs, and if so, when they anticipated ending their use of PCBs. The results of these contacts are summarized in Table 15.3-3.

All of these manufacturers plan to introduce non-PCB capacitors to replace the discontinued PCB products. In all cases, the new capacitors will use liquid phthalic acid esters (phthalates) as a direct substitute for PCBs. As a result of this material change, an increase of 6% in the size of the

TABLE 15.3-2

Manufacturers of PCB Industrial Capacitors in 1976

Company Name	Location of the Plant
General Electric Company	Hudson Falls, N.Y. Ft. Edward, N.Y.
Aerovox	New Bedford, Mass.
Universal Manufacturing Corp.	Bridgeport, Conn. Totowa, N.J.
Cornell Dubilier	New Bedford, Mass.
P. R. Mallory & Co., Inc.	Waynesboro, Tenn.
Sprague Electric Co.	North Adams, Mass.
Electric Utility Co.	LaSalle, Ill.
Capacitor Specialists Inc.	Escondido, Calif.
Jard Corp.	Bennington, Vt.
York Electronics	Brooklyn, N.Y.
RF Interonics	Bayshore, L.I., N.Y.
Axel Electronic, Inc.	Jamaica, N.Y.
Tobe Deutschmann Labs.	Canton, Mass.
Electro Magnetic Filter Co.	Sunnyvale, Calif.

Source: Versar Inc., PCBs in the United States: Industrial Use and Environmental Distribution, Springfield, Va.: National Technical Information Service, (NTIS PB 251 402/3WP), February 25, 1976, p. 89. Updated by Versar in later studies, Contract 68-01-3259.

Table 15.3-3

Manufacturers of Small Liquid Dielectric AC Capacitors

Company	Small Capacitor Sales (1975)* Million $/year	Status of PCB Use as of Late 1977
General Electric	30	No PCBs used
Aerovox	24	PCBs inventory sufficient until June 1978
Universal Mfg.	13	Will end PCB use by mid 1978
P. R. Mallory	10	PCBs inventory sufficient through March 1978
Cornell Dubilier	7	No information available
Jard Corporation	4	Will end use of PCBs during first quarter, 1978
Electric Utility Co.	3	PCBs inventory sufficient through mid 1978
Others	3	No use of PCBs after 1977

Source: Office of Environmental Affairs, U.S. Dept. of Commerce capacitor is required to provide the same electrical function. As a result of the size increase, some manufacturers who use capacitors in their products will have to redesign to allow room for the larger capacitors. Capacitors using metallized plastic film and phthalic acid ester liquid dielectrics are being tested; if successful, such units would be the same size as equivalent PCB capacitors.

The phthalates are more flammable than PCBs, and satisfactory fire safety can be achieved only by incorporation of adequate circuit breakers (pressure or thermal types) which will prevent rupture of the capacitor case following electrical failure of the capacitor. Substantial testing has been required to prove the adequacy of these circuit breaker devices to the satisfaction of the users of the capacitors because of the possibility of substantial product liability claims should a fire problem develop with the non-PCB units. The development and testing requirements have delayed the introduction of the non-PCB capacitors. However, none of the manufacturers of small capacitors contacted anticipate using PCBs after mid 1978. Use of PCBs until then will be based on existing inventories, as Monsanto stopped shipping PCBs in October, 1977, and no importation of PCBs is planned by any capacitor manufacturer.

The switch to phthalic acid esters will increase the demand for this class of chemical by approximately twenty million lb/year, compared to a total production of about one billion lb/year. This two percent increase in demand will not significantly affect either the availability or price of this material.

Estimation of the unit cost impacts of the PCB ban regulations on the industrial capacitor segment of the market is difficult for several reasons. First, Monsanto significantly increased the price of PCBs during 1976 and 1977. These price increases reflected greater production costs due to environmental percautions in handling and shipping the material, plus costs incurred through Monsanto participation in the regulatory process. Monsanto was also in the position of supplying a unique product having a low price elasticity of demand. The anticipated regulations presented a high barrier to entry into this market for other possible manufacturers of PCBs, so Monsanto was in a monopoly position, and their pricing may have reflected this market condition in addition to general inflationary pressure on all commodity prices during this period. The net effect was to increase the price of PCB capacitors above what would have been expected under long term competitive conditions had there not been the threat of regulatory action on the manufacture and use of PCBs.

At present, both PCB capacitors and non-PCB capacitors are available, although from different manufacturers. The non-PCB industrial capacitors are selling for about ten percent more than the PCB units having the same functional characteristics. Since the manufacturers of non-PCB capacitors do not have the option of producing PCB units, this price increase may reflect the premium which users are willing to pay for avoiding any possible impacts of the ban regulations on their operations and inventory rather than reflecting increases in manufacturing costs. Equilibrium pricing would not be expected to result until PCB capacitors were no longer available.

The demand for capacitors is highly inelastic, because close substitutes are not available and the number of uses to which capacitors may be put are limited. Consequently, capacitor users will be confronted with prices for non-PCB units which reflect the additional costs of production of such units due to the proposed regulation. The increased price of PCB capacitors and the present competitive pressure on the price of non-PCB capacitors suggests that the long term price increase due to the banning of PCBs will be more than the present differential of 10 percent. A total price increase of 50 to 20 percent is perhaps a more reasonable estimate of the price increase for non-PCB capacitors.

Sales of PCB industrial capacitors in 1976 are estimated to have been approximately $51.7 million. Assuming relatively constant output and demand, a fifteen to twenty percent price increase for comparable non-PCB industrial capacitors will result in sales of from $59.5 to $62.0 million (using constant dollars). This suggests that users of industrial capacitors will pay approximately $7.8 to $10.3 million more for non-PCB units.

Manufacturers of electrical equipment which will use non-PCB industrial capacitors may face various redesign problems. For example, manufacturers of miniature electrical equipment, who specialize in optimizing space in the construction of their products, may find that the production of a new, larger capacitor makes the continuation of their miniaturized product line uncertain. Apart from the market for miniature equipment, most electrical equipment can be redesigned to accommodate the somewhat larger non-PCB capacitors at relatively little cost.

Capacitors represent a very small fraction of the total production (i.e., input) cost of a given appliance. Any price increases in final products due to employing non-PCB capacitors will be imperceptable to consumers - i.e., the increase in price per unit will be so small that the percentage change in quantity demanded will be very close to zero. It is expected that sales of electrical appliances will not be affected appreciably nor will there be any dramatic effects on employment in the capacitor production industry nor in the electrical appliance manufacturing industry.

Users of non-PCB industrial capacitors may face greater risks of fire as they switch to such units. Insurance rates will increase to reflect any increased fire losses, but only after a time lag sufficient for new risks to be incorporated into the experience record.

Any decrease in the expected service life of industrial capacitors will have a disproportionate effect on economic impacts due to the proposed regulations. It is estimated that fewer than two percent of all small capacitors fail before the equipment is scrapped due to obsolescence. The

Cost of replacing these capacitors includes out of service time and high labor costs, and may total ten times the retail price of the replacement capacitor. The cost of replacing failed capacitors may therefore be equal to 20 percent of annual industrial capacitor sales. If shortened service life results in an increase of the rate of failure to 5 percent of the non-PCB units prior to obsolescence, the increased replacement costs could be 50 percent of the value of the total small capacitor market.

15.4 Summary

Transitional Costs:

Redesign of equipment to accomodate larger capacitors

Long Term Costs:

Power factor capacitors

Price increase for non-PCB capacitors	$5.5 to 10.9 million per year

Industrial capacitors:

Price increase for non-PCB capacitors	$7.8 to 10.3 million per year
Increased fire risk	*
Decreased service life	*

Employment Effects: Not expected to be significant

*Insufficient data available to support estimate of impact.

16.0 TRANSFORMER MANUFACTURING

Liquid filled transformers containing a PCB based liquid known generically as 'askarel' have been used for many years in those installations where the risk of fire justified the use of a fire resistant fluid. Askarel transformers have been allowed to be installed in hazardous locations such as in buildings without the requirement for a fire proof vault or fire sprinklers. No substitute transformer liquids have yet been developed which have fire resistant properties equal to the PCB based askarel.

16.1 Requirements of the Proposed Regulations

The proposed regulations would prohibit the manufacture of new PCB tranformers after December 31, 1978, but classify continued use of existing PCB transformers except those used in railroad locomotives as use in a totally enclosed manner. The regulations would authorize certain minor maintenance of existing transformers for five years after the effective date of the regulation but would prohibit major rebuilding of failed units. It is assumed that authorization for minor maintenance would be granted on request after the five year servicing authorization has expired as such maintenance decreases the risk of catastrophic failure of transformers and minimizes the risk of loss of PCBs to the environment. Disposal requirements for failed askarel transformers are specified by the PCB Marking and Disposal Regulations, and these requirements would not be changed by the proposed PCB Ban Regulations.

16.2 Industry Structure, Production, and Sales

A review of Monsanto's customer list for PCBs in the early 1970s indicated thirteen companies which used PCBs to manufacture askarel transformers. These companies and the location of their transformer manufacturing plants are listed in Table 16.2-1. Production of askarel transformers averaged 5000 units per year in the early 1970s. When these companies were contacted by Versar in September, 1977, only one manufacturer was still producing askarel transformers, and it anticipated ceasing production of this type of unit prior to the end of 1977. All of these manufacturers produced both oil filled and askarel transformers in the same plants. Oil filled transformers are inter-

Table 16.2-1

U.S. Transformer Manufacturers Which Used PCBs After 1970

Company Name	Plant Location
Westinghouse Electric Corp.	South Boston, Va. Sharon, Pa.
General Electric Company	Rome, Ga. Pittsfield, Mass.
Research-Cottrell	Finderne, N.J.
Niagara Transformer Co.	Buffalo, N.Y.
Standard Transformer Co.	Warren, Ohio Medford, Oregon
Helena Corp.	Helena, Alabama
Hevi-Duty Electric	Goldsboro, N.C.
Kuhlman Electric Co.	Crystal Springs, Miss.
Electro Engineering Works	San Leandro, Calif.
Envirotech Buell	Lebanon, Pa.
R.E. Uptegraff Mfg. Co.	Scottsdale, Pa.
H.K. Porter	Belmont, Calif. Lynchburg, Va.
Van Tran Electric Co.	Vandalia, Ill. Waco, Texas

Source: Versar Inc., PCBs in the United States: Industrial Use and Environmental Distribution, Springfield, Va.: National Technical Information Service (NTIS PB 251 402/3WP), February 25, 1976, p. 89.

changable with askarel transformers in new applications provided that the installation is properly engineered. Other substitutes for askarel transformers are also available. The 140,000 askarel transformers presently in service total only two percent of the total number of power and distribution transformers in use.

16.3 Substitutes for PCB Transformers

The askarel transformers presently in service were specified because this type of liquid filled transformer offered advantages in size, reliability, and fire safety that were not available with other types of transformers. Alternatives to PCB transformers have always been available, although all of the other types of transformers have different design characteristics and none are direct substitutes for the PCB units. Therefore, eventual replacement of the existing PCB transformers will require that each of the present installations be re-evaluated and that the necessary engineering changes be made to allow use of the best available replacement unit. New transformer installations will be designed to make optimum use of the available non-PCBs transformers. The choice among the available alternate transformer types and materials depends on the requirements of each specific application and the characteristics of the available non-PCB units.

A number of alternatives to the use of PCBs in fire resistant liquid filled transformers and to the use of transformers which contain any dielectric liquid have been developed and are commercially available. These substitutes for PCB transformers differ in their performance characteristics, applicable fire code installation requirements, and cost. The following sections discuss the major types of substitute units which are available.

High Fire Point Liquid Insulated Transformers

The 1975 National Electrical Code and previous issues allowed only the use of askarel and dry type transformers in hazardous locations without vault protection. Askarel was essentially defined as PCB based liquid. The 1978 NEC has added a specification (Article 450-23) for 'High Fire Point Liquid Insulated Transformers' which can be used under these same conditions. The 'High Fire Point Liquid' must have a fire point of at least 300°C, and must not propogate flames.

Underwriters Laboratory presently lists three liquids as meeting the 'High Fire Point' property requirements for transformers operating at voltages below 600V:

Dow Corning 561

General Electric SF-97 (50)

SWS Silicones Corp. F-190

Factory Mutual Research has not yet completed developing formal approval requirements and procedures for 'High Fire Point Transformer Liquids'. However, based on preliminary tests, Factory Mutual has issued interim guidelines to its field offices that six silicone liquids and three hydrocarbon liquids could be accepted at Factory Mutual insured locations without special fire protection. The list of Factory Mutual accepted liquid includes:

Supplier	Designation	Type of Fluid
Dow Corning	DC 561	Silicone
Dow Corning	DC 200	Silicone
General Electric	SF-97	Silicone
Union Carbide	L-305	Silicone
SWS Silicones	F-101	Silicone
SWS Silicones	F-190	Silicone
RTE Corporation	RTEmp	Hydrocarbon
Gulf Oil Chemicals Co.	RF Dielectric Fluid	Hydrocarbon
Uniroyal	PAO-20E	Hydrocarbon

Mineral Oil-Filled Transformers

If fire safety were not a consideration, there would be no reason why oil-filled transformers could not be used in all applications. In the past, PCB-filled transformers have cost about 1.3 times as much as oil-filled units of the same capacity, and thus most users preferred the oil-type where possible. The oil-filled transformers are the same size as the askarel units, and are considerably lighter in weight. Also, mineral oil has somewhat better heat transfer characteristics than askarel, and an electrical arc in mineral oil results in breakdown products that are non-corrosive.

The major disadvantage to mineral oil is flammability; transformer mineral oil has a flash point of 145°C. If an arc occurs with the transformer, the breakdown products will be hydrogen and methane, both of which are flammable. Detailed records of such failures are maintained by the electrical industry. Fire Underwriters does not approve of the use of oils and other flammable liquids for indoor applications. Where oil-filled transformers are not specifically prohibited as on-site replacements for PCB-filled units, the National Electrical Code imposes certain restrictions upon their mode of installation.

Oil-filled transformers are used in almost all power transformer applications and for most substation distribution applications where the transmission line high voltage is reduced to 12.8 kv for local distribution. Most rural pole-mounted transformers which reduce the voltage to 220 volts are also oil-filled. The issue of flammability only becomes important where the distribution transformer must be buried, as in many urban applications, or located close to, within, or on the roof of the building it serves. PCB-filled transformers have, in the past, been used in most such applications. Oil-filled transformers can be used in these applications only if they are suitably isolated from flammable structures or if these structures are suitably safeguarded against fires. When transformers are located outside the building they service, the low-voltage power must be brought into the building via cables or insulated buses. This causes additional energy losses due to heating in the low-voltage transmission lines from the transformer to the point of use.

Open Air-Cooled Transformers

Transformers can be built without the use of a liquid cooling medium. One type of dry transformer that is quite successful, under limited conditions, is the open air-cooled transformer. In this design, cooling air is driven through the transformer by either natural convection or forced circulation. In those sizes where air-cooled transformers are available, they are about equal in price to askarel-filled transformers of the same kva rating. However, the following limitations prevent open-air-cooled transformers from being considered for many applications using askarel-filled transformers.

<u>Heat capacity:</u> The power drawn from a transformer usually varies over a wide range. The rating of a transformer is established by the power it can handle continuously without over-heating. If a liquid-filled transformer is operated at overload conditions for a short period of time, the liquid will act as a heat sink, absorbing the excess heat produced in the transformer without a rapid increase in temperature. The result of this thermal inertia is that liquid-filled transformers can operate at outputs of up to 200 percent of rated capacity for a period of one to two hours without damage. Air-cooled transformers do not have this heat sink effect and are limited to operating at a maximum service rating not much higher than the continuous rating. Where the current draw on the transformer does not vary greatly during the day, this limitation is not a problem. However, in most cases the variation in load requires dry transformer to have a 20 to 30 percent greater capacity than liquid-filled transformers in the same application.

<u>Dielectric strength:</u> The liquid coolant in a liquid-filled transformer also provides a significant level of electrical insulation between the various current carrying components within the transformer. Air has a much lower dielectric strength, and open-air-cooled transformers are limited to a maximum voltage of 25 to 40 kv.

The problem of electrical insulation is even more severe if the open-air-cooled transformer only operates intermittently. When the transformer is operating, the heat generated within the windings keeps the insulation dry, and maintains a high dielectric strength of this solid insulating material. However, when the transformer is not operating, the coils cool to ambient temperatures and the insulation can absorb moisture from the air which reduces its dielectric strength. Open air-cooled transformers must be thoroughly dried before being put into service after each cool period.

One other problem with air-cooled transformers is the tendency of dust to be attracted from the air to the coils by electrostatic forces. Dust can build up in the coils and block the flow of air, or it can form conductive paths and cause short circuits.

Open-air-cooled transformers are generally limited to dry, clean locations where the load requirements are fairly even and constant, and where the maximum voltage does not exceed 30 kv. Such transformers are being successfully used in large office buildings, particularly tall buildings where the transformers are located every few floors. Even in this application, though, conditions arise that exceed the capabilities of the transformer; for instance, in the Sears Tower in Chicago, which is over 1400 feet tall, the electric power is brought into the building and up to the distribution transformers at 128 kv, which is beyond the voltage limitations of open-air-cooled transformers.

Closed Gas-Filled Transformers

Transformers can be built with dry inert gas (usually at an elevated pressure) as a heat transfer medium. These transformers avoid the maintenance problems caused by moisture and dust in open air-cooled transformers, but they are similarly limited in overload capacity because of reduced thermal inertia compared to liquid-filled transformers.

Closed gas-filled transformers must be installed in pressure-tight containers due to the changes in gas pressure caused by changes in temperature. However, the maximum voltage ratings of gas-filled transformers can be equal to that of liquid-filled units.

A number of different gases have been used as heat transfer media in closed gas-filled transformers. The most common gas used in the U.S. is the fluorocarbon hexafluoroethane (C_2F_6). Nitrogen and sulfur hexafluoride have also been used successfully in certain applications. Helium has not been found to be a satisfactory gas for this application because its low dielectric strength results in corona discharges within the transformer. Hydrogen is unsatisfactory as any leak in the transformer would result in a severe fire hazard.

Because of the necessity for a pressure vessel container, gas-cooled transformers are 30 to 40 percent heavier than PCB-filled transformers, and cost two-thirds more (and twice as much as oil-filled transformers). In addition, the gas-filled transformers must be sized larger than oil-filled units to allow for the expected heavy load peaks of power consumption.

16.4 Relative Prices of Non-PCB Transformers

The relative prices of distribution transformers of the size and type commonly installed in office buildings are summarized in Table 16.4-1. If the RTEmp high fire point liquid filled transformer proves to be acceptable for installation without auxiliary fire protection, there should be no cost increases for new transformer installations resulting from the ban on the manufacture of PCB transformers. The open dry type transformers are also quite cost competitive with the PCB units for most applications.

Table 16.4-1[1]

Relative Transformer Prices

Type of Unit	Price: 1000 KVA Unit	Price: 2000 KVA Unit
Oil filled	$ 15,300	$ 23,300
PCB	19,900	30,300
RTEmp	18,400	28,000
Silicone	22,300	34,500
Open air cooled	20,700	35,000
Sealed gas cooled	30,600	46,600

Source: MCC Engineers, "Distribution Transformer Status - WTI Project", Memorandum to U.S. General Services Administration, June 1, 1977.

16.5 Compliance Costs

Clean-up Costs.

The only costs incurred by transformer manufacturers due to the ban on the use of PCBs will be clean up and disposal costs incurred in flushing PCBs from storage and material handling equipment prior to using this equipment to store high fire point liquids. This equipment consists primarily of storage tanks, filters, pumps, and piping. Clean up costs, including disposal of contaminated solvents, should not exceed $10,000 per plant, or a total one time cost impact of perhaps $100,000 in 1977 and 1978.

Cost of Substitutes

The 'high fire point liquid cooled transformers' and air cooled transformers will cost about the same to 10% more than askarel units depending on the acceptability of hydrocarbon base high fire point transformer liquids. Based on past sales of 5000 askarel units per year at an average price of $20,000, a 10% cost increase would increase to sales and costs to the users by (5000 x $20,000 x 10% = $10,000,000 per year). There should be no effect on total demand for transformers for new applications. The ban on rebuilding askarel transformers may increase the demand for new transformers by 1000 to 2000 units per year. This additional demand should be easily supplied as the transformer manufacturing industry as it has recently been operating at only about 60% of capacity.

Market structure should not be significantly affected as all of the former manufacturers of askarel transformers will have equal access to the 'high fire point transformer liquid' materials and technology. Access to this market segment will open to those transformer manufacturers who did not offer askarel as an alternative to oil. This will primarily afford a marketing opportunity to RTE Corporation which has never supplied askarel units but which has a strong market position in the high fire point liquid transformer market segment. The increased sales by RTE will probably be less than the total increase in transformer sales, so this small shift in market structure should not result in a net decrease in the sales by any of the other manufacturers.

Increased Fire Losses

It was implicitly assumed above that the high fire point liquids are satisfactory replacements for PCBs in terms of performance and fire saftey. In fact, the high fire point liquids can burn under certain conditions including exposure to an external fire, and can release flammable gases if an electrical arc occurs within the transformer. It will be several years until a complete evaluation of the relative transformer fire risks is completed by the Fire Safety Division of the National Bureau of Standards under a research project currently being funded by the U.S. Department of Energy.

It will not be possible to accurately predict the increased fire losses that may result from the use of substitutes for PCBs transformers until the work of the Bureau of Standards is complete. Any estimates made at this time must necessarily be based on rather crude assumptions. It could be assumed, for example, that the 20% price premium for askarel transformers vs oil filled transformers was justified by a decrease in fire losses. The use of a high fire point transformer liquid might achieve 95% of the additional fire safety that would otherwise be achievable by using askarel. The increased fire losses resulting from the use of the high fire point liquid filled units would then be one percent of the cost of the units. Based on a production of 7000 new and replacement units per year at an average price of $20,000 each, this loss would be $1,400,000 per year.

16.6 Summary

Transitional Costs

Clean up costs for manufacturers	$100,000	1978 only

Long Term Costs

Increased cost of non-PCB transformers	$0 to $10 million per year
Additional fire losses from use of non-PCB transformers	$1,400,000 per year (very rough estimate)

Employment

Increased demand for replacement transformers should generate employment equal to that lost in the transformer rebuilding segment of the industry (see Chapter 5). An additional 78 jobs would be expected in 1979.

17.0 TOTAL COST AND ECONOMIC IMPACTS

The preceding chapters have discussed the various costs which will result from compliance with the proposed regulations. Costs of decontaminating or scrapping existing equipment, preparation of spill control plans, and the costs associated with the ban on rebuilding askarel transformers are all transitional costs — the annual costs will eventually decrease to zero, though this may require 20 years or more. Cost increases due to the increased prices for non-PCB capacitors and transformers will be long term costs — they will be expected to continue indefinitely.

Economic impacts, as distinct from cost impacts, include employment effects, changes in market structure, and impacts on energy demand and the international balance of trade. These impacts, too, can be both transitional and long term.

17.1 Transitional Cost Impacts

See Table 17.1-1.

Table 17.1-1

Transitional Cost Impacts

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 17.1-1 (Con't)

Transitional Cost Impacts

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.

17.2 Long Term Cost Impacts

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

Diarylide Yellow Pigment (Chapter 14)

Increased cost of substitute pigments	$10 to 25 million/year
Total	$23 to 56 million per year

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

17.3 Employment Impacts

Item (Chapter)	No. of Jobs (1979)	Total Man Years
PCB transformers		
Rebuilding	-50	-1470
Railroad transformers (6)		
Retrofill and decontamination program	+55	+ 165
Oil Filled Transformers (7)		
Analysis	+42 to 106	+1235 to 3118
Disposal services	+69 to 110	+2029 to 3235
Mining Machines (8)		
Spill Prevention Plans	+ 2	+ 2
Electromagnets (9)		
Increased demand	+50	+25 to 32
Additional Labor for Operations without Magnets	+50	+ 17
Hydraulic Systems (10)		
Decontamination Program	+12	+ 24

Item (Chapter)	No. of Jobs (1979)	Total Man Years
Lost Production from closing of facilities during decontamination	potential for thousands of layoffs early in 1979 in the steel industry for several months	-500?
Spill prevention plans	+5	+ 5
Reporting requirements	+7	+ 7
Heat Transfer Systems (11)		
Decontamination program	?	?
Compressors (12)		
Decontamination program	+1	+ 1
Reclaimed Oil (13)		
Ban on reclamation of contaminated hydraulic fluid	-12 to 15	-24 to 30
Diarylide Yellow Pigments (14)		
Loss of jobs in manufacture of pigments	-200	Job losses offset by increased employment in manufacture of substitute materials.
Capacitor Manufacturing (15)	0	0
Transformer Manufacturing (16)	+15	+1470

17.4 Other Economic Impacts

No significant market shifts are anticipated to result from the ban on the use of PCBs in the manufacture of capacitors or transformers.

The only significant impact on energy demand will be for the oil required to replace the contaminated transformer oil, hydraulic fluid, heat transfer fluid, and compressor fluid which must be drained and incinerated as part of the decontamination program. This requirement will be insignificant when compared with total oil consumption, particularly since the increased demand for transformer oil will be spread over 20 years or more.

A number of minor effects on the balance of trade may be anticipated. The ban on the importation of PCB capacitors in foreign made electrical equipment might decrease the availability or slightly increase the price of imported appliances. The restriction on the PCB contamination of diarylide yellow pigments might end the importation of this material. However, the ban on recycling contaminated transformer oil would be expected to result in an increased demand for new oil, and the ban on the rebuilding of transformers will increase the number of new transformers being manufactured resulting in an increased demand for bauxite to make the aluminum wire used in their construction. Sufficient data is not available to support a quantitative analysis of these effects, and the total impact on the balance of trade is not expected to be significant.

No significant impacts on supplies of strategic materials were identified in the course of this study.

APPENDIX A

TOXIC SUBSTANCES CONTROL ACT

Public Law 94-469

90 Stat. 2003 *et seq*

(e) POLYCHLORINATED BIPHENYLS.—(1) Within six months after the effective date of this Act the Administrator shall promulgate rules to— Rules.

(A) prescribe methods for the disposal of polychlorinated biphenyls, and

(B) require polychlorinated biphenyls to be marked with clear and adequate warnings, and instructions with respect to their processing, distribution in commerce, use, or disposal or with respect to any combination of such activities.

Requirements prescribed by rules under this paragraph shall be consistent with the requirements of paragraphs (2) and (3).

(2)(A) Except as provided under subparagraph (B), effective one year after the effective date of this Act no person may manufacture, process, or distribute in commerce or use any polychlorinated biphenyl in any manner other than in a totally enclosed manner.

(B) The Administrator may by rule authorize the manufacture, processing, distribution in commerce or use (or any combination of such activities) of any polychlorinated biphenyl in a manner other than in a totally enclosed manner if the Administrator finds that such manufacture, processing, distribution in commerce, or use (or combination of such activities) will not present an unreasonable risk of injury to health or the environment.

(C) For the purposes of this paragraph, the term "totally enclosed manner" means any manner which will ensure that any exposure of human beings or the environment to a polychlorinated biphenyl will be insignificant as determined by the Administrator by rule. "Totally enclosed manner."

(3)(A) Except as provided in subparagraphs (B) and (C)—

(i) no person may manufacture any polychlorinated biphenyl after two years after the effective date of this Act, and

(ii) no person may process or distribute in commerce any polychlorinated biphenyl after two and one-half years after such date.

(B) Any person may petition the Administrator for an exemption from the requirements of subparagraph (A), and the Administrator may grant by rule such an exemption if the Administrator finds that— Petition for exemption.

(i) an unreasonable risk of injury to health or environment would not result, and

(ii) good faith efforts have been made to develop a chemical substance which does not present an unreasonable risk of injury to health or the environment and which may be substituted for such polychlorinated biphenyl.

An exemption granted under this subparagraph shall be subject to such terms and conditions as the Administrator may prescribe and shall be in effect for such period (but not more than one year from the date it is granted) as the Administrator may prescribe. Terms and conditions.

(C) Subparagraph (A) shall not apply to the distribution in commerce of any polychlorinated biphenyl if such polychlorinated biphenyl was sold for purposes other than resale before two and one half years after the date of enactment of this Act.

(4) Any rule under paragraph (1), (2)(B), or (3)(B) shall be promulgated in accordance with paragraphs (2), (3), and (4) of subsection (c).

(5) This subsection does not limit the authority of the Administrator, under any other provision of this Act or any other Federal law, to take action respecting any polychlorinated biphenyl.

SEC. 6. REGULATION OF HAZARDOUS CHEMICAL SUBSTANCES AND MIXTURES.

15 USC 2605.

(a) SCOPE OF REGULATION.—If the Administrator finds that there is a reasonable basis to conclude that the manufacture, processing, distribution in commerce, use, or disposal of a chemical substance or mixture, or that any combination of such activities, presents or will present an unreasonable risk of injury to health or the environment, the Administrator shall by rule apply one or more of the following requirements to such substance or mixture to the extent necessary to protect adequately against such risk using the least burdensome requirements:

(1) A requirement (A) prohibiting the manufacturing, processing, or distribution in commerce of such substance or mixture, or (B) limiting the amount of such substance or mixture which may be manufactured, processed, or distributed in commerce.

(2) A requirement—

(A) prohibiting the manufacture, processing, or distribution in commerce of such substance or mixture for (i) a particular use or (ii) a particular use in a concentration in excess of a level specified by the Administrator in the rule imposing the requirement, or

(B) limiting the amount of such substance or mixture which may be manufactured, processed, or distributed in commerce for (i) a particular use or (ii) a particular use in a concentration in excess of a level specified by the Administrator in the rule imposing the requirement.

(3) A requirement that such substance or mixture or any article containing such substance or mixture be marked with or accompanied by clear and adequate warnings and instructions with respect to its use, distribution in commerce, or disposal or with respect to any combination of such activities. The form and content of such warnings and instructions shall be prescribed by the Administrator.

(4) A requirement that manufacturers and processors of such substance or mixture make and retain records of the processes used to manufacture or process such substance or mixture and monitor or conduct tests which are reasonable and necessary to assure compliance with the requirements of any rule applicable under this subsection.

(5) A requirement prohibiting or otherwise regulating any manner or method of commercial use of such substance or mixture.

(6)(A) A requirement prohibiting or otherwise regulating any manner or method of disposal of such substance or mixture, or of any article containing such substance or mixture, by its manufacturer or processor or by any other person who uses, or disposes of, it for commercial purposes.

(B) A requirement under subparagraph (A) may not require any person to take any action which would be in violation of any law or requirement of, or in effect for, a State or political subdivision, and shall require each person subject to it to notify each State and political subdivision in which a required disposal may occur of such disposal.

(7) A requirement directing manufacturers or processors of such substance or mixture (A) to give notice of such unreasonable risk of injury to distributors in commerce of such substance or mixture and, to the extent reasonably ascertainable, to other persons in possession of such substance or mixture or exposed to such substance or mixture, (B) to give public notice of such risk of injury, and (C) to replace or repurchase such substance or mixture as elected by the person to which the requirement is directed.

Any requirement (or combination of requirements) imposed under this subsection may be limited in application to specified geographic areas.

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