than comparable oil-filled units; the average cost is $12,000 per magnet. In addition, Eriez offers a proprietary air-cooled electromagnet which has Underwriters Laboratory approval for use in dirty and dusty environments. These units cost an average of $10,000 each.

Servicing: The PCB electromagnets are similar in construction to askarel transformers, and it is anticipated that the magnets are subject to the same failure mechanisms, expected service life, and service practices as the transformers. If the average remaining service life of the PCB electromagnets is ten years, the magnets would be expected to fail at the rate of twenty units per year. Although rewinding failed magnet coils would probably cost 60% of the cost of a new magnet, rebuilding is banned by the regulation. The transportation and labor costs would be expected to be the same whether a magnet is replaced or rebuilt, so the effect of the ban on rebuilding is to forego a potential savings of 40% of the purchase cost of a new magnet each time a PCB magnet fails. Total annual costs would be expected to be (20 magnets per year x 40% of $12,000 per magnet =) $96,000 per year. Total costs attributable to the ban on rebuilding PCB electromagnets will be $960,000.

Disposal: The PCB Ban Regulations authorize the disposal of drained PCB electromagnets in chemical waste landfills. The previous PCB Disposal and Marking Regulations (EPA, 1978a) authorized only incineration. Since incineration is not available for magnets, a petition for alternating disposal means would have had to have been submitted to the EPA each time a magnet required disposal. There is no information in the record on which to base an estimate of the cost of preparing and processing such petitions, but this cost has been eliminated by the Ban Regulations.

9.4 PCBs Controlled by the Regulation

The PCB electromagnets presently in use contain about 207,900 pounds of PCBs. The regulations do not affect the continued use of these

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magnets. The effect of the ban on rebuilding these magnets will be to eliminate the loss of PCBs to the atmosphere that might occur during the rebuilding process. If these losses were 1 to 10 pounds per magnet, as estimated in Chapter 4 for askarel transformers, the regulations would be expected to reduce the amount of PCBs entering the environment by (200 magnets x 1 to 10 pounds PCBs per magnet =) 200 to 2000 pounds of PCBs.

9.5 Summary - Economic Impacts

Ban on rebuilding: $96,000 per year; $960,000 total.

Disposal: Elimination of costs of preparing and processing petitions for disposal by means other than incineration.

9.6 Cost Per Pound of PCBs Kept from the Environment

$$\text{Cost per pound} = \frac{\$960{,}000}{200 \text{ to } 2000 \text{ pounds}} = \$480 \text{ to } \$4800 \text{ per pound PCBs}$$

MONS 013297

10.0 HYDRAULIC SYSTEMS

10.1 Present Use of PCBs in Hydraulic Systems

Prior to 1972, PCB based hydraulic fluids were marketed by Monsanto under the trade name Pydraul® for use in hydraulic systems where superior fire resistance was necessary for protection of life and property.* A previous EPA sponsored study reported that sales of PCB based hydraulic fluids during the period 1970-1971 totaled over 13.5 million pounds to 585 different firms (Versar, 1978, p. 65). General Motors Corporation reported that GM used PCB based fluids in the following types of systems:**

Metal die-casting equipment
Trim press hydraulics
Plastic injection molding machines
Metal melting furnace tilt hydraulics
Industrial elevators
Iron foundry pouring equipment
Molten iron holding furnace equipment
Induction hardening machine hydraulics
Flame hardening equipment
Heat-treating furnace hydraulic systems
Forge furnace hydraulic systems
Forge press hydraulic systems
High tension welding machines
Loading dock levelers
Fork lift trucks
Other small miscellaneous systems.

Uses of PCBs by GM were reported to be: Die-casting - 56%; Foundry - 35%; other uses - 9%. A review of Monsanto's customer list for 1970-71 indicated that 80% of the purchasers of hydraulic fluid were primarily die-casting operations and the other 20% were primarily steel companies (Versar, 1978, p. 65).

*Hesse, John L. 1975. "Polychlorinated Biphenyl Usage and Sources of Loss to the Environment in Michigan." National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Illinois. Washington, D. C.: Office of Toxic Substances, U. S. Environmental Protection Agency (Report No. EPA-560/67-75-004), p. 129.

**Letter from Mr. W. R. Johnson (General Motors Corporation) to EPA dated August 7, 1978.

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When Monsanto discontinued the sale of PCB based hydraulic fluids in 1972, they recommended to their customers (1) that there was no need to drain the systems and (2) that compatible Monsanto hydraulic fluids could be used to replace leakage. Most hydraulic systems require the addition of new or reclaimed fluid at a rate of two to ten times the system capacity each year to replace leakage losses. It is fairly common practice to recover leaked fluid and to process it for reuse. Available data on residual PCB levels in hydraulic systems indicate that the concentration of PCBs ranges from 60 ppm to as high as 50% in a few machines (Versar 1978, p. 65). 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.

Mr. Owain Fowkes of RADCO Corp. reported that the hydraulic fluid which is commercially reclaimed sometimes contains up to 6000 ppm PCBs.* Therefore, it is possible that the use of reclaimed hydraulic fluid has resulted in the PCB contamination of hydraulic systems which never contained PCB based Pydraul® fluids.

Die-casting machines: The analysis of the proposed PCB Ban Regulations suggested that PCB based hydraulic fluid may have been used in as many as 1000 die casting machines. This estimate was based on the assumptions that 80% of the hydraulic fluid sold during 1970-71 was used in die-casting machines, that the annual makeup requirement of new fluid to replace leakage is equal to the liquid capacity of the hydraulic system, and that the average die-casting machine has a capacity of 500 gallons of hydraulic fluid (Versar, 1978, pp. 65-66). Mr. Johnson of General Motors suggested that this estimate may be in error because not all of the hydraulic fluid purchased by companies classified as primarily die-casting concerns was used in die-casting machines; GM used only 56% of their PCB

*Telephone conversation with L. Fourt (Versar), September 19, 1977, as reported in Versar, 1978.

MONS 013299

hydraulic fluid in die-casting machines and the rest in associated equipment and in their steel foundry operations.* The Outboard Marine Corporation plant in Waukegan, Illinois, contains 135 die-casting machines, 60 associated trim presses, 30 electric melting furnaces, and several other furnaces plus numerous other systems, all of which contained PCB based hydraulic fluid prior to 1971.** The average capacity of the die-casting machines at Outboard Marine is 350 gallons; GM reported that its die-casting machines had an average capacity of 460 gallons at one plant and 1580 gallons at another plant.

Mr. William Sharp of the Society of Die Casting Engineers stated that die-casting machines are long-lived pieces of equipment with some 35- to 40-year-old machines still in operation. These machines are in use by 1500 to 1800 separate companies, and perhaps 35% of the companies used synthetic hydraulic fluids (not necessarily PCB based). There is a very active market for used machines.***

Based on the available information and assuming that 80% of the companies buying fluid had die-casting machines, that 60% of the fluid purchased by these companies was used in this type of machine, and that the average annual requirement for makeup fluid was equal to the system capacity of 400 gallons, the number of die-casting machines that once used PCB based fluid may have been as high as 700 machines as calculated in Table 10.1-1. No information is available on the number of companies that own PCB contaminated die casting machines. However, it should be noted that not all the machines that used PCB based hydraulic fluid can be identified from the records because many machines have been resold since 1971. If the total number of die-casting machines in use is 10,000 to 15,000 (estimate based on an average annual production of 500 machines and an assumed average ownership of 6 to 10 machines per company), only 5 to

*Letter from Mr. W. R. Johnson (General Motors Corporation) to EPA dated August 7, 1978.

**Oral testimony of Hugh Thomas (Outboard Marine Corporation) at the hearings on the PCB Ban Regulations, August 25, 1978.

***Oral testimony by William Sharp (Society of Die Casting Engineers) at the hearings on the PCB Ban Regulations, August 25, 1978.

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Figure 10.1-1

Calculation of Number of Die-Casting Machines that Used PCB Based Hydraulic Fluids

Total sales of PCB hydraulic fluid, 1970-1971	13,500,000	pounds PCBs
÷ Number of years	2	
= Annual sales of PCB hydraulic fluid	6,750,000	pounds per year
÷ Weight of fluid per gal	11.5	pounds per gal
= Gallons PCBs per year	587,000	gallons per year
x Assumed fraction purchasing companies owning die-casting machines	x .8	
= Gallons PCBs purchased by companies owning die-casting machines	470,000	
x Assumed: 60% used in die-casting machines as makeup fluid	x .6	
= Gallons per year used as makeup fluid	282,000	
÷ Assumed: 400 gallons per year per die-casting machine required as makeup fluid	÷ 400	
= Number of die-casting machines using PCB based hydraulic fluid	704	

MONS 013301

7% of the machines presently in service ever used PCB based hydraulic fluid. However, many of the other machines may presently be contaminated with PCBs because of the practice of reclaiming hydraulic fluid.

Other hydraulic systems: General Motors reported use of PCB based hydraulic fluids in systems ranging from 50 gallons to 4000 gallons, with most of the systems being in the 300 gallon range.* Comments submitted by Armco, Inc., (dated August 3, 1978) summarized the results of testing 50 heat transfer and hydraulic systems with an average capacity of 422 gallons. This is reasonably consistent with an average hydraulic system capacity of 350 gallons. It implies that perhaps 1,000 other hydraulic systems used PCB based fluids in the years 1970-71, assuming these systems require proportionately as much hydraulic fluid for makeup as do die-casting machines. These systems were probably owned by all of the companies having die-casting machines plus perhaps an additional 100 steel companies.

Total PCBs presently in use: Total capacity of all of the hydraulic systems that at one time used PCB based hydraulic fluids may be (700 die-casting machines x 400 gallons per machine + 1000 other systems x 350 gallons per system =) 630,000 gallons. GM reported that 80% of their die casting systems have PCB concentrations below 500 ppm*; Outboard Marine reported that recent spot checks of their machine show PCB levels around 100 ppm, compared to a range of 210 to 1400 ppm in 1976 and 1977**. It is therefore likely that the average concentration of PCBs in hydraulic fluid is between 100 ppm and 500 ppm if the single group of die casting machines known to contain 50% PCB fluid is excluded as a special case. If the average density of the presently used hydraulic fluid is ten pounds per gallon, the total amount of PCBs in use in hydraulic systems may be (630,000 gallons x 10 lb per gallon x 100 ppm to 500 ppm PCBs =) 630 to 3150 pounds of PCBs.

*Letter from W. R. Johnson (General Motors Corporation) to EPA dated August 7, 1978.

**Letter from Hugh Thomas (Outboard Marine Corporation) to EPA dated August 3, 1978.

MONS 013302

10.2 Requirements of the PCB Ban Regulation

Continued use of hydraulic systems contaminated with PCBs in excess of 50 ppm is authorized until January 1, 1984, subject to the following requirements:

- Testing: Required for all machines that ever contained a PCB based hydraulic fluid by July 1, 1979, and at least annually thereafter as well as three months after each refilling performed to reduce the concentration of PCBs to below 50 ppm.
- Marking: Hydraulic systems containing liquids contaminated with over 50 ppm PCBs must have the special PCB label applied.
- Retrofill: Retrofilling or topping off with a hydraulic fluid containing less than 50 ppm PCBs is required within 6 months after any test which shows that the concentration of PCBs exceeds 50 ppm.
- Disposal of contaminated fluid: Hydraulic fluid containing over 50 ppm PCBs must be disposed of by incineration in special approved PCB incinerators or by incineration in other facilities such as high efficiency boilers approved by the EPA Regional Administrators. This material can also go to Chemical Waste Landfills or high efficiency boilers if it is between 50 and 500 ppm.
- Storage: Special storage facilities required for the storage for reuse or processing of hydraulic fluid contaminated with more than 50 ppm PCBs.
- Disposal of contaminated machine after liquid is drained for incineration: Essentially not regulated (either salvage or disposal as non-hazardous waste allowed) provided the fluid is first drained from the machine and, if the fluid contained over 1000 ppm PCBs, the hydraulic system is flushed with clean solvent.
- Reclaiming of contaminated hydraulic fluid: Hydraulic fluid contaminated with more than 50 ppm PCBs may be reclaimed for reuse in the owner's hydraulic systems only if it is treated to reduce the concentration of PCBs to below 50 ppm. Reclaiming for purposes of resale is banned unless this activity is exempted by the EPA.

10.3 Cost Impacts of the PCB Ban Regulation

Testing: Most of the hydraulic systems that once used PCB based fluids have since been refilled with fluids based on phosphate

MONS 013303

esters. Analysis of phosphate esters for the presence of PCBs requires a rather time consuming treatment of the sample and extraction of the PCBs before injecting the prepared sample into a gas chromatograph. In their written comment dated August 3, 1978, to the EPA on the proposed PCB Ban Regulations, Armco Inc., stated that their average cost to analyze hydraulic fluid for PCBs "...is probably closer to $200 than the Versar estimate of $300, once the GC equipment is set up to specifically analyze for PCBs. Laboratories which would only occasionally analyze such samples would probably incur costs exceeding $300 per sample." Only seven of the 50 systems checked by Armco contained PCBs in excess of 1000 ppm.

Identification of all systems that contained PCB hydraulic fluids will require the analysis of the fluid in many systems which might have contained PCBs. As many as 2500 die-casting machines (Versar, 1978, p. 75) and perhaps as many other hydraulic systems might have to be tested to identify the approximately 1700 systems which used PCB fluid and to evaluate the extent of contamination from the use of reclaimed fluid. The cost of the required sampling and analysis program will include sampling and administrative costs of perhaps $20 per system in addition to the laboratory costs of perhaps $250. Costs for the analysis program required by July 1, 1979, might total (1700 to 5000 systems x $270 per sample =) $460,000 to $1,350,000. Since the average PCB concentration is probably in the range of 100 to 500 ppm, most of the systems will have to be retrofilled within six months and tested again within the next year. A second retrofill and another test might be required. Total testing costs could easily exceed $1,000,000.

Since the concentration of PCBs will continually decrease in the hydraulic systems because of retrofilling, leakage, and replacement of the fluid, it is expected that the concentration of PCBs in almost all systems will have decreased to less than 50 ppm by the end of the five years authorized for continued use of contaminated system, and that the testing requirements would not apply to the systems after that time.

MONS 013304

Retrofill: Based on the experience reported by GM and Armco, it is expected that most of the systems that ever used PCB based hydraulic fluid will be found to be contaminated at levels exceeding 50 ppm. If this is the case, retrofilling will be required for perhaps 1700 hydraulic systems having an average capacity of about 400 gallons. Armco stated that the Versar estimate of $14 per gallon for retrofilling was reasonable;* GM estimated the material cost alone to be $17 to $19 per gallon;** Outboard Marine estimated a cost of $8,000 for a 350 gallon system, or an average of $23 per gallon.*** Total costs of the first retrofilling program would be (175 systems x 400 gallons per system x $14 to $23 per gallon =) $9,800,000 to $16,100,000. According to data presented by both Armco and GM, such a retrofilling program might be expected to reduce the concentration of PCBs in the liquid by about 90%. Perhaps 10% of these systems might have PCBs in excess of 50 ppm after being retrofilled, so a second retrofill, and in a few cases even a third retrofill, would be required. Total costs for these subsequent retrofills might be $1,000,000 to $1,500,000.

Topping off systems with PCB concentrations only slightly above 50 ppm may result in lowering PCBs levels below 50 ppm without incurring the costs of draining and refilling the entire system.

Disposal of contaminated fluid: Special high temperature incineration of liquids contaminated with PCBs in excess of 500 ppm was required by the PCB Disposal and Marking Regulations. The effect of the PCB Ban Regulations is to extend this requirement to fluids containing between 50 and 500 ppm PCBs. The most recent available price for this incineration is $55 per 55 gallon drum (Rollins, 1978) plus drum costs of perhaps $15 per drum, transportation of $.02 per pound, and drum disposal costs of $30, or a total cost of $.22 per pound for contaminated hydraulic

*Armco, Inc. "Main Comments," received by EPA August 3, 1978.
**Letter from W. R. Johnson (General Motors Corporation) to EPA dated August 7;, 1978.
***Letter from Hugh Thomas (Outboard Marine Corporation) to EPA dated August 3, 1978.

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fluid. If all of the fluid in the calculated system capacity of 630,000 gallons required special disposal because of this change in the regulation, increased disposal costs of (630,000 gallons x 10 lb per gallon x $.22 per pound =) $1.4 million would be incurred. If the use of contaminated reclaimed fluid has resulted in an increased number of systems contaminated with PCBs in excess of 50 ppm, this disposal cost might increase by a factor of 2 or 3 or more. The required retrofilling will generate a quantity of liquid equal to the calculated system capacity, resulting in an additional disposal cost of $1.4 million.

The regulations authorize the EPA Regional Administrators to approve alternative incineration facilities for liquids such as contaminated hydraulic fluids. It is possible that approval for the use of high efficiency boilers might lower the disposal costs substantially, but no estimate can be made of the resulting decreases in disposal costs.

Marking: The requirement that the special PCB label be applied to systems found to contain from 50 to 500 ppm PCBs should not cost more than $2 per machine. Even if (as an upper bound estimate) 2500 such contaminated systems were found, total labeling costs would not exceed $5,000.

All of the liquid that is removed from the hydraulic systems during the retrofill and decontamination activities will also have to be placed in labeled containers prior to being shipped for disposal. At a cost of $2 per 55-gallon drum, labeling costs for disposal could total (630,000 gallons x 2/55 gallons per drum x $2 per label =) $46,000.

Special storage areas: Liquids contaminated with 50 to 500 ppm PCBs will be allowed to be stored in drums in temporary storage areas prior to disposal if a Spill Prevention, Control and Countermeasure Plan has been prepared for the temporary storage area in accordance with 40 CFR 112.

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There is no information available in the record that would support an estimate of the number of additional SPCC plans that would have to be prepared under this requirement. However, it is assumed that perhaps one third of the 585 firms that bought PCB hydraulic fluid during the period 1970-1971 will be found to have contaminated hydraulic systems and that some of the 200 firms will therefore have to prepare SPCC plans covering temporary storage areas for PCB contaminated liquid.

Disposal of contaminated machines: It is not anticipated that any of the machines will be scrapped before they are decontaminated to a level below 50 ppm PCBs. Therefore, there should be no additional disposal costs due to the PCB Ban Regulations.

Recycling of contaminated hydraulic fluid: New phosphate ester based hydraulic fluid costs about $7.60 per gallon (Versar 1978, p. 68). According to the comments of GM, the following treatment techniques have been found to be incapable of reducing the concentration of PCBs to below 50 ppm: PAC carbon filter, Florsil filter column, and clay. Open air distillation of contaminated phosphate ester fluid resulted in excess oxidation of the fluid. Outboard Marine has described a vacuum distillation procedure which reduces the PCB content of the hydraulic fluid by 50% at a cost of $3.75 to $4.00 per gallon*. Mr. Rober Damiani of RADCO Industries in his oral comments at the August 25, 1978 hearings, described in general terms a fractional distillation process that is "effective in removing PCB. In fact, a number of runs were made in which PCB concentration was reduced to below 50 ppm." Mr. Damiani stated that RADCO has not developed a process that will reliably reduce the level of PCBs to below 50 ppm and that their present process achieves a reduction to 100 ppm. He stated that the result of a 50 ppm requirement will be to "decrease process yield, and subsequent economics -- 10 to 20 percent below that expected with a 100 ppm specification."

If it is assumed that the total amount of contaminated fluid is available for recycling once per year and that there is presently 725,000

*Oral testimony by Hugh Thomas (Outboard Marine Corp.) at the August 25, 1978 hearings on the proposed PCB Ban Regulation.

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gallons of such fluid in service, the successful development of a reclaiming process might reduce costs for new fluid by $2.80 per gallon (based on reclamation costs 20% higher than mentioned by Outboard Marine Corp.) or by a total of $350,000 to $1,700,000 per year. It is not known whether the requirement that recycled fluid contain less than 50 ppm PCBs will significantly affect the availabilty of such a reclamation service; the total impact of the regulation therefore cannot be estimated.

10.4 PCBs Controlled by the Regulation

In section 10.1, it was estimated that hydraulic systems contaminated with more than 50 ppm PCBs may contain from 630 to 3150 pounds of PCBs. If the use of these systems were not regulated, all of this material would be expected to leak out of the systems and eventually enter the environment. The requirement that the contaminated systems be retrofilled by the end of 1979 will reduce total losses to leaks prior to the retrofilling. Since hydraulic systems often require make-up fluid equal to their volume each year, the losses of PCBs prior to the retrofilling may equal 25% of the PCBs present in the systems. The effect of the regulation, therefore, is to prevent the loss to the environment of .75 x (630 to 3150 lbs =) 470 to 2390 pounds of PCB.

10.5 Summary - Economic Impacts

Testing:

1979	$460,000 to 1,350,000
1980-1984	$1,000,000 total

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Retrofill:	$10,800,000 to $17,600,000*
Disposal of fluid:	$1,400,000*, **
Marking:	$46,000
Special storage areas of SPCC plans:	Insufficient data available to estimate
Ban on recycling contaminated hydraulic fluid:	Insufficient data available to estimate. Maximum possible impact = $350,000 to $1,700,000 per year for one or two years.

10.6 Cost Per Pound of PCBs Kept from the Environment

Cost per pound = ($460,000 to $1,350,000 + $1 million + $10.8 to $17.6 million + $1.4 million + $700,000 to $3.4 million)/470 to 2390 pounds = $6,000 to $53,000 per pound PCBs

*May be significantly higher if the use of reclaimed hydraulic fluids has contaminated hydraulic systems that never used PCB based fluids.
**May be somewhat reduced if EPA approves alternative incinerators for hydraulic fluids.

MONS 013309

11.0 HEAT TRANSFER SYSTEMS

11.1 Present Use of PCBs in Heat Transfer Systems

In his letter to the EPA dated August 4, 1978, Mr. W.R. Corey of Monsanto estimated that there were 450 heat transfer systems using PCB based fluid in 1972 when Monsanto discontinued sales of PCBs for those systems. A review of a Monsanto customer list, however, indicated that sales of PCB heat transfer fluids were made to 533 different companies during the years 1970 and 1971 (Versar, 1978, p. 76). Mr. Corey estimated that one half of the heat transfer systems had capacities between 50 and 500 gallons and that the other half had capacities averaging 2000 gallons. This implies that the average system capacity was 1300 gallons, or about 15,000 pounds of PCB. The total Monsanto sales of heat transfer liquid during 1970 and 1971 was 8.2 million pounds, or enough liquid to fill about 550 average systems. Total use of PCB heat transfer liquid in the United States since 1929 has been estimated at 21 million pounds, including both new installations and makeup fluid (Versar, 1978, p. 75).

Mr. Corey of Monsanto estimated that over 90% of the heat transfer systems using PCBs were converted to alternative non-PCB fluids in 1970-72 and that current system PCB levels in the industry range from around 100 ppm to three percent. Mr. Jack Pulley of Dow Corning, in his reply comment dated October 9, 1978, stated that Dow Corning replaced PCB fluids in their heat transfer systems about five years ago and that these systems still contain PCBs in concentrations from 1/2% to about 2% in the new non-PCB heat transfer fluid. Data is also available for one other heat transfer system that contained 14,000 gallons of PCB based fluid. Draining and flushing prior to replacement of the liquid reportedly reduced the concentration of PCBs to two percent (Versar 1978, p. 76). Monsanto and Dow Corning agreed that it is technically infeasible to reduce the concentration of PCBs in contaminated systems to below 50 ppm.

11.2 Requirements of the PCB Ban Regulation

All heat transfer systems that ever used PCB based fluids will be considered PCB articles because their surfaces are presently in contact

MONS 013310

with a liquid containing over 50 ppm PCBs. These systems will be allowed to remain in service until July 1, 1984, subject to the following conditions:

- Use: After October 1, 1979, no heat transfer system containing a liquid with a PCB concentration above 50 ppm may be used in the manufacture or processing of any food, drug, or cosmetic.

- Testing: Required by July 1, 1979, for all heat transfer systems that ever contained a PCB based heat transfer fluid. Systems must be retested within three months after each time the fluid is replaced to reduce the concentration of PCBs to below 50 ppm. Records of all tests must be kept for five years after the concentration of PCBs is reduced to 50 ppm.

- Retrofill: Within six months following any test that indicates the presence of more than 50 ppm PCBs in heat transfer fluid, the fluid must be drained and replaced with fluid that contains less than 50 ppm PCBs. Topping off that results in reduction of PCB concentration to less than 50 ppm is also allowed.

- Marking: Required for all systems found to have PCB concentrations in the fluid in excess of 50 ppm.

- Disposal of liquid containing over 50 ppm PCBs: For liquids with greater than 500 ppm PCBs, incineration is required in an approved PCB incinerator. Liquids between 50 and 500 ppm PCBs can go to approved high efficiency boilers or chemical waste landfills.

- Storage: Special storage facilities required for the storage of PCB contaminated heat transfer fluid.

- Disposal of contaminated machine after liquid is drained: High temperature incineration required in an approved PCB incinerator or disposal of machine in an approved chemical waste landfill.

11.3 Cost Impacts of the PCB Ban Regulation

Testing: The liquids used to replace the PCB based heat transfer liquids may be analyzed for PCBs by a method similar to that used

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to analyze for PCBs in transformer oil. The cost of such an analysis should be about the same as the price of $60 per sample previously quoted by Versar for the transformer oil analysis (Versar 1978, p. 41). Sampling and order handling costs might increase this cost to $100 per sample, or a total of $45,000 to $60,000 for the analysis required by July 1, 1979, on the 450 to 600 contaminated systems presently in use. Additional testing required within three months of each system retrofill is included below as part of the retrofill costs.

Retrofill: The regulations require that the concentration of PCBs in heat transfer systems be reduced to less than 50 ppm by July 1, 1984. Most of the systems now contain about two percent PCBs. Monsanto stated that draining most heat transfer systems will remove at least 90% of the fluid, and that new replacement heat transfer liquid will cost about $8 per gallon.* Disposal of contaminated fluid containing over 500 ppm PCBs in an approved PCB incinerator would cost from $1.20 per gallon (in tank truck lots) to $2.10 per gallon (in 55 gallon drums) (Rollins, 1978). Transportation would add about $.02 per pound or $.16 per gallon to this cost (Versar, 1978). Since one-half of the systems have capacities of over 2000 gallons, 80% of the liquid may be in these large systems which would generate truckload lots of fluid when drained. The average disposal cost would therefore be $1.54 per gallon, including transportation. Incineration costs for liquids contaminated with less than 500 ppm PCBs were quoted at about one-half the rate for the more contaminated liquids (Rollins, 1978). This would be equal to a cost of $.81 per gallon, including $.02 per pound transportation. If each system were drained every six months of 90% of the fluid and then refilled with new fluid that did not contain PCBs, any PCBs that were adsorbed on the vessel walls or absorbed into porous gasket material would have a chance to diffuse into the liquid between retrofills. Each draining would therefore remove 90% of the PCBs from the system, progressively reducing the concentration from the present 20,000 ppm (2%) to 2,000 ppm, then to 200 ppm, and finally to 20

*Letter from W. R. Corey (Monsanto) to EPA dated August 4, 1978.

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ppm after the third retrofill. If the average system capacity is 1,300 gallons, the 450 to 600 contaminated systems presently contain (1300 x 450 to 600 gallons =) 585,000 to 780,000 gallons. The cost to reduce the concentration of PCBs from the present 2% to below 50 ppm will be $15 million to $20 million as calculated in Table 11.3-1.

Since each system must be analyzed within three months after each retrofilling, a total of (450 to 600 x 3 =) 1350 to 1800 additional analyses will be required at a cost of $100 each, for a total additional analytical cost of $135,000 to $180,000.

Marking: The marking of heat transfer systems containing liquids contaminated at levels above 500 ppm PCBs is required by the Disposal and Marking Regulations (EPA, 1978a). Since no systems are expected to be contaminated at levels between 50 ppm to 500 ppm, the change in the definition of PCB mixture from 500 ppm to 50 ppm in the Ban Regulation is not expected to change the number of heat transfer systems requiring the application of a special label.

The drums and trucks used to transport the contaminated liquid to the incinerator for disposal will also require special labeling. Since this is already required for liquids containing over 500 ppm PCBs, the effect of the Ban Regulation will be to add this requirement to the disposal of the liquid from the third retrofill. If four labels are required per machine @ $2, total additional labeling costs will be (450 to 600 machines x 4 labels x $2 per label installed =) $3600 to $4800.

Storage for Disposal: Since the required disposal areas will have to be installed at each location that uses contaminated heat transfer systems to meet the requirements of the Disposal and Marking Regulations, no additional cost will result from the PCB Ban Regulations.

Disposal of Heat Transfer Systems: There is no information in the record that will support any estimate of the number of heat transfer systems that will be scrapped before they are decontaminated to PCB levels below 50 ppm.

MONS 013313

Table 11.3-1

Cost of Retrofilling Heat Transfer Systems to Meet 50 ppm Limit on PCB Concentration

Number of contaminated systems	450-600
x Average System Capacity	1,300 gallons
= Total quantity of fluid	585,000 to 780,000 gallons
x Weight per gallon	8 lbs per gallon
x Concentration of PCBs	2% PCBs
= Pounds of PCBs in fluid	93,600 to 124,800 lbs PCBs
First Retrofill	
Total quantity of liquid	585,000 to 780,000 gallons
x Drainage efficiency	.9
= Gallons to be disposed of and replaced	526,500 to 702,000 gallons
PCB Content @ 2%	84,200 to 112,300 lbs PCBs
Cost of replacement fluid @$8.00/gal	$4,212,000 to $5,616,000
+ Cost of disposal @ $1.54/gal	$810,800 to $1,081,000
+ Labor @ 16 hours/system @ $15/hour	$108,000 to $144,000
= Total cost of first retrofill	$5,130,000 to $6,840,000
Second Retrofill	
PCB content @ 2000 ppm	8,420 lbs to 11,230 lbs PCBs
Total cost of second retrofill	$5,130,000 to $6,840,000

MONS 013314

Table 11.3-1 (Continued)

Third Retrofill

PCB content @ 200 ppm	842 lb to 1,123 lbs PCBs
Cost of replacement and labor	$4,320,000 to $5,760,000
+ Cost of disposal @ $.81/gal	$426,000 to $569,000
= Total cost of third retrofill	$4,746,000 to $6,329,000
Total cost to reach 50 ppm	$15,000,000 to $20,000,000
Total lbs PCBs removed	93,500 lb to 124,700 lbs PCBs

MONS 013315

However, since disposal of machines containing fluid with more than 500 ppm PCBs was required by the Disposal and Marking Regulations, the Ban Regulations only affect the disposal of those machines contaminated at levels between 50 ppm and 500 ppm.

The previously established requirement that all heat transfer systems contaminated at levels above 500 ppm be disposed of in approved chemical waste landfills would have resulted in significant costs.

As a very rough estimate, the volume of each system using heat transfer fluid might be ten times the volume of the fluid which it contains. The total volume of material requiring disposal in approved landfills might then be (450 to 600 systems x 1300 gallons/system x 10 gallons system volume/liquid volume 7.43 gallons/cubic foot =) 800,000 to 1,000,000 cubic feet at a cost of $3 per cubic foot (Versar 1977, pp. 2-13). Because of the uncertainty in this estimate, actual disposal cost might be considerably higher than this figure. All of these costs would have been incurred, under the requirements of the Disposal and Marking Regulations which defined PCB mixtures as those containing over 500 ppm PCBs. The effect of the required decontamination will be to decrease the eventual disposal costs by $2.4 million to $3 million.

11.4 PCBs Controlled by the Regulation

Monsanto claimed that leakage from heat transfer systems was infrequent and would seldom exceed 5% of the capacity of the system in any single incident. If retrofilling contaminated heat transfer systems were not required, as much as 10% of the PCBs presently in the systems would be spilled or leaked because of pump seal leaks and accidents. The remaining amounts of PCBs would be incinerated as required by the Disposal and Marking Regulations. If spill cleanup were 80% effective, the effect of the regulation would be to reduce the amount of PCBs entering the environment to 2% of the 93,600 to 124,800 pounds presently in the machines, or by 1872 to 2496 pounds.

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11.5 Summary - Economic Impacts

Testing:	
Initial	$45,000 to $60,000
Following retrofilling	$135,000 to $180,000
Retrofill:	$15,000,000 to $20,000,000
Disposal:	
Cost savings because systems are decontaminated	$2,400,000 to $3,000,000
Total	$12,780,000 to $17,240,000

11.6 Cost per Pound of PCBs Kept from the Environment

Cost per pound = $\frac{\$12,780,000}{1872 \text{ lbs}}$ to $\frac{\$17,240,000}{2496 \text{ lbs}}$ = $6827 to $6907 per pound PCBs (average = $6870/lb)

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12.0 COMPRESSORS

Prior to 1972, Monsanto marketed a PCB based lubricant under the trade name Turbinol® 153 for use in turbine type compressors. This liquid was apparently used in a number of natural gas pipeline compressors (Versar 1978, p. 78). Although the liquid was flushed out and replaced with non-PCB fluid in the early 1970s, residual levels of PCBs have been found in at least a few of the machines.*

12.1 Requirements of the PCB Ban Regulation

Compressors containing a liquid contaminated with more than 50 ppm PCBs may be used until May 1, 1980, provided a PCB label is applied to each contaminated machine. These compressors may not be used after January 1, 1980, unless they have been decontaminated to a level below 50 ppm PCBs.

12.2 Impacts of the PCB Ban Regulation

Versar previously estimated that there were perhaps ten compressors that would be affected by the proposed PCB Ban Regulations and stated that Columbia Gas and Texas Eastern had been contacted for additional information on the number of contaminated compressors and the cost and feasibility of decontamination (Versar 1978, p. 78).

In his letter to the EPA of August 4, 1978, Mr. Willard Young of Texas Eastern Transmission Corporation stated that Texas Eastern would be able to reduce the level of PCBs in their compressors to below 50 ppm by the end of 1978 "by another cycle of draining, flushing, and installing new lubricants." He did not include any information on the cost of this procedure or the number of compressors requiring decontamination.

In his letter to the EPA of August 4, 1978, Mr. Robert Welch, Jr., of Columbia Gas System Service Corporation stated that forced shutdown of compressors on January 1, 1979, could have a significant effect on the

*Letter from Willard T. Young (Texas Eastern Transmission Corporation) to EPA dated August 4, 1978.

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delivery of natural gas, "depending on the number of units affected." Mr. Welch also stated that the economic impact analysis of the proposed regulations (Versar, 1978) was deficient because the cost of service disruption was not estimated. However, Mr. Welch did not furnish any data on the number of contaminated compressors operated by the industry or by Columbia Gas, nor did he include any information on the difficulty, cost, and time required to decontaminate such compressors. Therefore, it is still not possible to estimate the total economic costs of the regulatory requirements which ban the continued use of contaminated compressors. Since Texas Eastern apparently will be able to meet these requirements, total direct cost of the decontamination program should not exceed the $200,000 previously estimated (Versar 1978, p. 79). The requirement that the decontamination program be completed by the end of 1979 gives the industry time to complete the program during the slack summer season, so there should not be any costs caused by service disruptions.

12.3 PCBs Controlled by the Regulation

There is no information in the record that will support any estimate of the amount of PCBs presently in use in compressors. Therefore, no estimate can be made of the amount that will be controlled by the regulation.

12.4 Summary - Economic Impacts

Decontamination costs — $200,000

13.0 RECLAIMED OIL*

13.1 Present Status of PCBs in 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. use of new (virgin) refined oil and availability of used oil for recycling are presented for the year 1975 in Table 13.1-1.

Data generated by Recon Systems** 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

*This chapter is adapted from Chapter 13 of Versar, 1978. The EPA promulgated the rules affecting the use of reclaimed oil with essentially no changes from the proposed regulations.

**Weinstein, Norman J., (Recon Systems, Inc.), Waste Oil Recycling and Disposal, EPA-670/2-74-052, Princeton, N.J.: August, 1974 (as cited in Versar, 1978).

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Table 13.1-1

New Oil Usage and Waste Oil Availability for Recycling in 1975*

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	6
	Subtotals	413		96
Lube Oils Purchased by U. S. Government		32	.50	16
	GRAND TOTALS	2,376		1,154

*Wainstain, 1974 (as cited in Versar 1978, p. 81).
**Fraction available for recycling after losses in use and to environment.

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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 13.1-1. Summary data for disposition and usage from Figure 13.1-1 are as follows:*

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 shown in Figure 13.1-1 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 by the industrial concern generating the waste oil or by processors.

The primary sources of waste oil available to collectors are service stations and other automotive-related facilities. Industrial and

*Versar 1978, p. 83.

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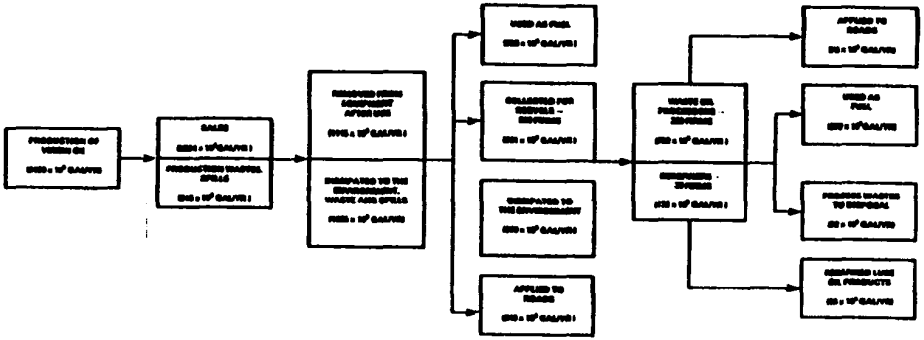

SOURCE: ADAPTED FROM TABLE 28, P. 100 OF WEINSTEIN, 1971 *

FIGURE 13.1 1. DISTRIBUTION AND UTILIZATION OF WASTE OIL IN THE UNITED STATES DURING 1970-71

*Cited in Versar 1978, p. 82.

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aviation facilities are also significant sources. A significantly larger fraction of available oil is collected in urban areas than in suburban or rural areas. According to 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 re-refined 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 primarily by four companies, results in a product which is marketed as hydraulic oil.

13.2 Requirements of the Proposed Regulations

The disposal of oil contaminated with PCBs in excess of 500 ppm was regulated by the PCB Marking and Disposal Regulations (EPA 1978a). The PCB Ban Regulations change the definition of PCB used in the Marking and Disposal Regulations to include all mixtures containing more than 50 ppm PCBs. Under the provisions of the ban regulations, oil contaminated with PCBs in excess of 50 ppm must be identified, segregated for purposes of disposal, and disposed of in accordance with one of the approved methods. Oil containing measurable amounts of PCBs less than 50 ppm may be processed for any use including fuel or reclaimed lubricating or hydraulic oil, but it may not be used as road oil or as a constituent of any sealant, coating, or dust control agent.

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13.3 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),* 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 from leaks in the hydraulic system.** 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.

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. They did recommend that replacement fluids 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 0.006 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.

*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 Agricultrue, 1972 (as cited in Versar 1978, p. 84).

**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 (as cited in Versar 1978, p. 84).

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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 (Versar 1978, p. 85).

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 (Weinstein, 1974). 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) (Versar 1978, p. 85).

The extent of PCB contamination of this oil was studied on a limited basis by the EPA National Enforcement Investigation Center (NEIC) in Denver.* 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, 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

*Testimony of Robert Magruder, (Continental Forest Industries) presented at the U.S. EPA informal hearings on the PCB ban regulations at Washington, D.C., July 15, 1977.

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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.* 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.**

13.4 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.*** These interferences result in false positive indications of the

*Monsanto Chemical Company, Aroclors for ——, St. Louis, Mo.: undated (as cited in Versar 1978).

**Reams, George, (United States Department of Interior, Denver, Colorado), "Polychlorinated Biphenyls," File HLS 3-3-10h, June 13, 1977 (as cited in Versar 1978).

***Hofstader, R. A. (Exxon Research and Engineering Co.); Lisk, D. J., Sache, 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 (as cited in Versar 1978).

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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 13.1-1). At an application rate of 1/2 gallon per square yard, this is sufficient to oil 45,000 miles of roadway 24 feet wide (Versar, 1978, p. 87). 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

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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 (Versar 1978, p. 87).

(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 Corporation. This material is an organic resin in a water emulsion which is sold in large quantities for $.40/gallon plus transportation, and is 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 are summarized in Table 13.4-1.

The use of synthetic road oiling materials such as Coherex® may be more or less expensive than the use of used motor oil depending on the local supply and price of the used oil. The present choice between the use of used oil and synthetic materials apparently depends on local supply and cost conditions. The total cost resulting from an effective ban on the use of waste oil would certainly be no greater than $31.7 million per year, as calculated in Table 13.4-1, and might even result in an overall cost savings as claimed by Witco Chemical.

*Letter from Victor Shepard (Witco Chemical Corp.) to EPA dated September 23, 1978.

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Table 11.4-1

Cost of Substituting COHEREX® for Used Motor Oil in Road Oiling for Dust Control

Coherex®:	Bulk Purchase Price	$.40/gal.
	Transportation @.02/lb. (Verser 1977)	.17/gal.
	TOTAL	$.57/gal.
Material Cost for Coherex®:	1/6 gal./yd^2	.09
Minus:	Used Oil: 1/2 gal./yd.^{2} @.08 to .30/gal.*	.04 to .15
Equals:	Increased Cost (Savings) per sq. yd.	$.05 (.06)
x 14080 yd^2 per mile of road, 24 ft. wide =		$704 (845)
x 45,000 miles =		$31,680,000/year ($38,025,000/year)

*Price range reported by Victor Shepard (Witco Chemical Corp.) for supplies of used oil. Letter to EPA dated September 23, 1978.

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Users Other than Road Oilers: About 27 million gallons per year of transformer oil will not be available to collectors. However, oil diverted from road oiling may more than offset this loss of 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.* 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, hauling contaminated oils to chemical waste incinerators or high efficiency boilers 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 be to lower the price. Waste oil can be

*Haugh, T. W., "Re-refined Oil: An Option That Saves Oil, Minimizes Pollution," Science, p. 1108-1110, September 17, 1976 (as cited in Versar 1978, p. 89).

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used as a supplemental fuel with coal. This use recovers the fuel value of the oil and would destroy any PCBs that might be present in the oil. Since PCB contaminated oils may be incinerated in large boilers, and since the use of waste oil with coal in boilers is relatively troublefree, this use is probably very elastic. If coal burning plants can absorb the increased supply, which seems likely, the price decrease should be negligible.

Hydraulic Oil Re-refiners: 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 (Chapter 10). In most cases, the reclaiming process removes no more than 10% of these PCBs.* 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. The present status of PCB reduction technology is discussed in Chapter 10.

Industrial Waste Oil Generators: Those industries whose waste oil contains more than 50 ppm PCBs will have to incur disposal costs of up to $.75 per gallon (see Chapter 6). Even industrial oil contaminated with less than 50 ppm PCBs may be avoided by waste oil collectors. This may not be a major problem for companies that have large high efficiency boilers. Oil burning boilers can use a mixture of waste and virgin oil. Mr. Magruder of 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.

13.5 PCBs Controlled by the Regulation

The provision of the regulation that prohibits the use of oil containing any measurable amounts of PCBs as a coating or dust control

*Telephone conversion, Dwain Powkes (RADCO Corp.) with L. Pourt (Versar), September 19, 1977 (as cited in Versar 1978, p. 90).

**Testimony on Robert Magruder (Continental Forest Industries). Presented at the U.S.E.P.A. informal hearings on the PCB Ban Regulations at Washington, D. C., July 15, 1977.

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agent will affect only those waste oils that contain less than 50 ppm PCBs, since the disposal of the more highly contaminated oils is controlled by other provisions of the regulation. The only available data indicate that waste oils are presently contaminated with PCBs to levels of 3.2 to 19.4 ppm (section 13.3). No information is available as to the sources of the oils for which this data was obtained, and diversion of transformer oil and contaminated industrial oils to high efficiency boilers might significantly reduce the concentration of PCBs in the remaining waste oil. However, if it is assumed that all of the oil affected by this provision of the regulation is contaminated at levels of 11 ppm (average of 3 ppm and 19 ppm), then the PCB content of the used oil that is available for recycling will be (11 ppm x 8 pounds per gallon x (651 million gallons automotive oil + 54 million gallons gas engine oils + 31 million gallons railroad engine oils + 16 million gallons U. S. government lube oils*) =) 66,176 pounds.

Approximately 12.9% of new lubricating and industrial oil production has been applied to roads, 41.5% used as fuel, and 3.3% re-refined as lube oil. Diversion of the 12.9% that has been used on roads will control (.129 x 66,176 pounds PCBs =) 8537 pounds of PCBs. If this oil is used as fuel and re-refined as lube oil products in the same ratio as above, (41.5/(41.5+3.3) =) 93% will be used as fuel and 7% will be re-refined. About one half of the re-refined oil will be lost to the environment and the other half will be used as fuel, so the effect of the regulation will be to divert about 96.5% of the 8537 pounds per year of PCBs used on roads to fuel use. Since many of the boilers using this oil may not meet the criteria established for high efficiency boilers, perhaps 2% of the PCBs in the waste oil will not be destroyed. Therefore, the total amount of PCBs that will be destroyed in the boilers rather than applied to roads will be (8537 pounds PCB per year x .965 diverted to fuel use x .98 destruction efficiency =) 8073 pounds PCBs per year. The actual amount diverted to the environment may be lower if the controls on the disposal of transformer oils and contaminated industrial oils decreases the amount of PCBs in the remaining waste oil.

*Table 13.1-1.

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13.6 Summary - Economic Impacts

Compliance Costs

Road Oil - increased costs of virgin or synthetic material (first several years)	$0 to 31.7 million/year
Road Oil - increased cost of obtaining adequate supplies of segregated used motor oil after level of PCBs in used motor oil drops below detectable limits.	$0 to $6.4 million/year

13.7 Cost Per Pound of PCBs Kept from the Environment

Cost per pound =

$$\frac{\text{0 to \$31.7 million per year}}{\text{8073 pounds/year}} =$$

0 to $3925 per pound PCBs

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14.0 PCBS AS UNINTENTIONAL PRODUCT CONTAMINANTS

14.1 Current Production

There are a number of commercial chemical processes which produce PCBs as an unintentional byproduct in concentrations over 50 ppm. These include the production of two classes of pigments, a new aluminum smelting process, and several other proprietary chemical processes.

Phthalocyanine pigments: Phthalocyanine blue and green pigments are produced in two steps.* The first step is the production of crude pigment using, in most cases, trichlorobenzene as a solvent.* In this instance, a side reaction involving the trichlorobenzene is the source of the PCBs. The crude is then further processed to produce a number of different blue and green pigments. In 1976, production and imports of phthalocyanine blue and green pigments were 13,200,000 lbs* with a value of roughly $87.6 million. Testing indicates that the majority of this type of pigment is contaminated with over 50 ppm PCBs, though there is considerable doubt concerning the validity of the test method which was used.**

Currently, the only major domestic crude manufacturer which does not use trichlorobenzene as a solvent is DuPont.*** They reportedly use kerosene and have developed pigments based on the properties of the crude they produce. In addition, Phthalchem uses a mixed solvent system which has trichlorobenzene as one of the components. Testing indicates that this crude may be contaminated below 50 ppm; again, however, the analytical method has not been validated.

*"Main Comments of Dry Color Manufacturers Association ...." dated August 7, 1978, p. 16.

**Testimony of the Dry Color Manufacturers Association at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C. August 30, 1978.

***Oral testimony of Arthur Hopmeier, (Phthalchem Inc.), at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

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Imports of blue crude, primarily from Japan, supplied over 56% of the U.S. market in 1976.* In addition, low-PCB crudes are currently available in commercial quantities from at least one Japanese supplier. This is a recent development, and any increase in demand for this product could not be met for roughly a year.** Also, Mr. MacDonald Smith of Sun Chemical testified that this low PCB crude was of inferior quality.***

Diarylide pigments: Diarylide yellow, orange, and red pigments are made by reaction of precursors which include dichlorobenzidine as an essential component. A minor side reaction results in the decomposition of the dichlorobenzidine to produce 3,3'- dichlorobiphenyl.****

Sales of diarylide pigments in 1976 were about 9,760,000 pounds with a value of $41 million.**** There are currently no substitutes for the diarylide pigments, which are used in printing ink, textile ink, plastics, and paints. In 1969, diarylide yellow (the diarylide with by far the highest production) accounted for 84% of all yellow pigments produced in the United States.****

Aluminum smelting: Alcoa has developed a new smelting process which inadvertently produces over 50 ppm of decachlorobiphenyl.***** The PCBs are produced in a preliminary step involving the production of aluminum chloride through the reaction of alumina with chlorine in the presence of coke. The PCBs and other contaminants are removed in the second step, which is the electrolysis of the aluminum chloride to produce metallic aluminum.

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*Oral testimony of Arthur Hopmeier, (Phthalchem Inc.) at the PCB Manufacturing, Processing, Distribution in Commerce and Use Bans Hearings, Washington, D.C., August 30, 1978

**Letter to EPA from W. C. Parle, (Harmon Colors) July 11, 1978.

***Oral comments of Hugh MacDonald Smith (Sun Chemical Corporation) at the PCB Manufacturing, Processing, Distribution in Commerce and Use Bans Hearings, Washington, D.C., August 30, 1978, p.107.

****"Main Comments of Dry Color Manufacturers Association ..." dated August 7, 1978, Table 3.

*****Information on this aluminum smelting process and the resulting PCBs was taken from the letter from James S. Boyt (Alcoa) to EPA dated October 10, 1978.

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This process has several advantages over conventional aluminum smelting. These benefits include elimination of fluoride emissions, reduced energy consumption, and improved product purity. The energy savings possible with this process are considerable. Conventional smelting requires 8 KWH per pound of aluminum produced. This new process requires 4.5 KWH per pound, a savings of nearly 44%. Using these figures, a 300,000 ton per year smelter could save up to 1.95 million KWH per year.*

In addition, the production of the aluminum chloride in the above process has a number of energy and process advantages compared to conventional aluminum chloride production methods.

Other chemical processes: Phillips Petroleum and Dow Corning, both have chemical processes that produce over 50 ppm PCBs. The Phillips process is still experimental and apparently involves the use of PCBs as a chemical intermediate.** Dow Corning states that during the production of a chemical intermediate, PCBs, apparently largely monochlorinated biphenyl, are produced at levels between 50 and 500 ppm.*** Tennessee Eastman also had a chemical process that produced over 50 ppm PCBs.**** However, Tennessee Eastman subsequently advised EPA that it had modified its process and "because of these modifications, the only time a concentration of PCB in excess of 50 ppm occurs is after processing to concentrate and dispose of the PCBs, as specifically contemplated at 43FR24805....."*****

Polychlorinated terphenyls (PCTs) formerly produced by Monsanto are known to have been contaminated with over 50 ppm of PCBs. The only uses of PCTs discussed at the hearings were a number of applications in microscopy. This use has been authorized. Similar applications involve the use of certain Aroclors. These uses have also been authorized.

*Letter to EPA from James S. Boyt (ALCOA) dated October 10, 1978.
**Letter to EPA from Phillips Petroleum Co. dated August 4, 1978.
***Letter to EPA from Jack Pulley (Dow Corning Corporation) dated October 10, 1978.
****Letter from J. C. Edwards (Tennessee Eastman Company) to EPA dated August 7, 1978.
*****Letter from Elliott Stern (Tennessee Eastman Company) to EPA dated December 21, 1978. (Letter in record of TSCA Exemption Docket No. 1)

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14.2 Requirements of the PCB Ban Regulations

It is assumed here that none of the operations described above qualify as being "in a totally enclosed manner." Therefore, the manufacture, processing, distribution in commerce, and use of any chemical containing over 50 ppm PCBs (including phthalocyanin and diarylide pigments and the products of the Alcoa smelting process) are banned 30 days after the date of promulgation of the PCB Ban Regulation except in those cases specifically exempted by EPA.

14.3 Economic Impact

Pigment Manufacturers: The impact the ban regulations will have on those manufacturers who produce products contaminated with low levels of PCBs will depend on the actions taken by the EPA in response to petitions for exemption from the regulation. For the purposes of this analysis, an upper bound economic impact will be estimated assuming that no exemptions are granted before enforcement of the regulations begins. A lower bound economic impact will be estimated assuming that all exemptions are granted by the EPA. This second assumption also presumes that, where necessary, exemptions for processing and distribution in commerce will be granted. The Interim Procedural Rules for Polychlorinated Biphenyls (PCB's) Ban Exemption (EPA, 1978d)*, state that only petitions from those affected by the manufacturing ban will be considered. Therefore, separate petitions will be required for processing, distribution in commerce, and use exemptions.

*EPA. 1978d. "Part 750 - Procedures for Rulemaking Under Section 6 of the Toxic Substances Control Act: Interim Procedural Rules for Polychlorinated Biphenyls (PCB's) Ban Exemption." Federal Register, November 1, 1978, pp. 50905-50907.

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The processes in use by Dow Corning, Alcoa, and Phillips Petroleum must cease 30 days after the rule is promulgated unless EPA has granted or is considering a petition for exemptions (EPA 1978d). The small amount of economic data available are insufficient to support an estimate of the impact this will have.

Upper Bound Estimate: There are three companies that manufacture crude phthalocyanine blue using trichlorobenzene as a solvent; they are American Cyanamid, Chemtron, and Phthalchem.* Phthalchem uses a mixed solvent system which has trichlorobenzene as one of the components; the others use pure trichlorobenzene. Dupont uses kerosene; Hercules Powder and Thomasett use a dry process. The crude produced by each of these companies may contain over 50 ppm PCBs although Phthalchem pigment has consistently shown less than 50 ppm PCBs.** In the absence of a valid analytical method for determining PCB levels in this material, however, this study will assume that all three companies must modify their processes to comply with the regulations. Kerosene appears to be the most feasible solvent to replace trichlorobenzene. Mr. Arthur Hopmeier of Phthalchem testified that it would require 12 months and cost roughly $250,000 for him to modify his plant.** Mr. Paul Malchick testified that the two Chemtron plants could be converted to the use of kerosene solvent for a total cost of $1,500,000 but that considering the age and condition of Chemtron's

*Letter from Arthur Hopmeier (Phthalchem Inc.) to EPA - August 4, 1978.
**Testimony of Arthur Hopmeier (Phthalchem Inc.) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

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equipment, it would be economically sounder for them to spend $5,000,000 construct a new plant.* They would also attempt to purchase low-PCB crud from Japan in order to meet their needs during the 24-30 months necessary to construct this plant.* Purchase of the required 3 million pounds of crude per year would cost roughly $4.5 million. No data were given by American Cyanamid. Based on (1) a Chemtron estimate of $750,000 to convert each of their aged plants and (2) Mr. Hopmeier's estimate that Phthalchem plant would require less to convert than other plants,** the cost for American Cyanamid is estimated at $500,000. The total cost for plant conversion is:

$$\$250,000 + \$1,500,000 + \$500,000 = \$2,250,000$$

In addition, Harmon Colors produces either a special crude or further processes purchased crude in trichlorobenzene to produce a phythalocyanine pigment which contains 575 ppm of PCBs. This pigment is used by the automotive industry and its manufacture has been authorized by the State of Michigan. It would cost Harmon Colors roughly $2 million to construct a new plant capable of producing this pigment in an alternative solvent.***

Four companies presented information which indicates that they may be producing diarylide pigment with PCB levels in excess of 50 ppm. They are: (1) Chemtron, (2) Pope, (3) Ridgeway Color and Chemical, and (4) Sun Chemical. It appears that the diarylide pigments could be produced with less than 50 ppm PCBs if some process modifications were made. There are some estimates on the cost of adjusting the manufacturing process to reduce the concentration of PCBs. Mr. Paul Malchick of Chemtron estimated that it would cost $50,000 to modify their manufacturing and, because the process modifications will put them out of compliance with their NPDES

*Testimony of Paul Malchick (Chemtron) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

**Testimony of Arthur Hopmeier (Phthalchem Inc.) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978.

***Letter to EPA from W. C. Parle (Harmon Colors) dated July 11, 1978.

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permit, an additional $250,000 will be required.* Two other companies estimate their cost for complying with a 50 ppm limit as follows:**

Company	Initial Capital Cost	Increased Annual Operating Expense
1	$750,000	$250,000
2	$200,000	$375,000-500,000

Three of the four companies listed would have an average conversion cost of $333,000. If this average is used as the cost for the fourth company, the total conversion cost could be $1.33 million. Increased operating costs may amount to $345,000 per company.** Although some types of diarylide pigments already contain less than 50 ppm PCBs, one to two years will be required to reduce the level of PCBs to below 50 ppm in all of these pigments.**

The manufacturing cost estimates for both types of pigments include only those costs directly attributable to plant conversion and to increases in operating costs. If the manufacturers are forced to cease production of all pigments that contain over 50 ppm PCBs, there will be additional costs associated with lost production and future loss of customers who convert to substitutes or foreign suppliers. There may also be costs associated with the disposal of contaminated pigments presently in inventory. There is not enough data in the official record to support an estimate of these costs, but the data which are present deserve attention and seem to indicate that these additional costs could substantially exceed the conversion costs.

*Testimony of Paul Malchick (Chemtron) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, Washington, D.C., August 30, 1978, p. 126.
**Letter to EPA from Donald Morgan, (Dry Color Manufacturers Association) dated August 7, 1978.

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In 1976, production and imports of phthalocyanine blue totaled 13,200,000 pounds* with a value, after processing into pigments, of roughly $87.6 million. Imports of blue crude (not pigment), primarily from Japan (85%), supplied over 56% of the U.S. market in 1976.** The majority of the imports are high-PCB crude. Low-PCB crude is being produced in Japan, but an increase in demand could not be met for a year.***

Sales of diarylide pigments in 1976 were 9,760,000 pounds with a value of $41 million. In addition, roughly 275,000 pounds were imported.****

Sales for phthalocyanine and diarylide pigments in 1976 totaled $131 million. Total sales of all organic pigments in 1976 were $261 million, compared with $200 million for inorganic pigments.**** Thus, the two classes of pigments in question account for over 25% of the domestic market.

The percentage of the industry that would be forced to cease production in response to a manufacturing ban is not known, but it is estimated to be closer to 50% than to 10%.***** This implies that up to one quarter of the domestic organic pigment producing industry would have to close down. In addition, a company that can no longer produce yellow and/or blue pigments may lose other portions of its sales because "customers demand a full line of colors."***** The minimum conversion time given at the hearings was 12 months, so in the event an exemption is not granted, domestic manufacturers would be affected for at least 6 months and would not be back to full capacity for 18 months. The potential for substitution of different pigments types and the ease with which production of low- or non-PCB pigment could be expanded are not known, but it does appear

*Letter to EPA from Arthur Hopmeier (Phthalchem) August 4, 1978.
**Testimony of Arthur Hopmeier at the PCB Manufacturing, Processing, Distribution, and Use Bans Hearings, August 30, 1978.
***Letter to EPA from W. C. Parle (Harmon Colors) July 11, 1978.
****"Main Comments of Dry Color Manufacturers..." dated August 7, 1978.
*****Testimony of Donald Morgan (DCMA) at the PCB Manufacturing, Processing, Distribution in Commerce, and Use Bans Hearings, August 30, 1978.

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that imports could not immediately fill any shortages. However, the available information indicates that extensive ink, dye, and paint reformulation will be required, equipment may require modification or replacement, and printing quality will suffer.

There could be additional costs once domestic manufacturers begin producing low- or non-PCB pigments. In those cases where process modification rather than solvent substitution is used, it may be necessary to test each batch of pigment for PCBs as it is produced. Chemtron states that they have made process modifications that reduce the PCB concentration to low apparent levels but that there may be occasional batches with higher concentrations due to mechanical failure or operator error.* In addition to the testing, production of a batch with over 50 ppm would be illegal production which could be subject to a possible fine. The lowering of the permissible limit from 500 tp 50 ppm PCBs would result in the disposal of additional batches of pigment.

Lower bound estimate: The lower bound estimate assumes that the following eight "pigment" companies will individually apply for (and will receive) exemptions:

American Cyanamid
Apollo Colors
Chemtron
Harmon Colors
Phthalchem
Pope
Ridgeway Color and Chemical
Sun Chemical

*Letter from Paul Malchick (Chemtron) to EPA dated August 3, 1978.

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It is also assumed that each company will apply for two exemptions: one for manufacturing and one for processing and distribution in commerce.

Preparation of the required petition and attendance at the hearing may require one man-week per company. Considering that, due to the importance of the issue and the legal aspects involved, much of this work is usually handled by lawyers and higher level company officials, a labor rate of $200/day will be assumed. In addition, total travel expenses of $600 for two people per company will be assumed. The total expense for the eight companies listed using the above figures is $19,200.

If EPA grants the manufacturers an exemption from the "manufacturing," "processing," and "distribution in commerce" bans, the pigment that is manufactured could only be used to formulate inks, etc., if the purchasers were in turn exempted from the "processing" and "distribution in commerce" bans. Further, since the inks will contain PCBs at levels below 50 ppm because of dilution of material containing more than 50 ppm PCBs, all material containing the pigments will have to be labeled as "PCBs," and the users will require exemptions from the "use" ban.

There is no information in the record that suggests whether EPA will consider class action petitions for exemptions, or that would suggest how EPA may handle the labeling problem. Therefore, no estimate can be made of the resulting economic impacts of these provisions of the regulations.

Other chemicals: No information exists in the record to support any estimate of the impact of the ban regulation on companies such as Alcoa and Dow Corning that are inadvertently manufacturing PCBs in chemicals other than dry pigments. These chemical processes will be subject to the same ban provisions or, alternatively, the need to obtain exemptions from the manufacturing, processing, distribution in commerce, and use ban regulations as described above for dry pigments.

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14.4 PCBs Controlled by the Regulation

Pigments: Data reported by Sun Chemical Corp. suggests that the average PCB concentration in diarylide pigments is 95 ppm and in phthalocyanine pigments is 170 ppm.*

Total annual sales of the phthalocyanine pigments are 13.2 million pounds of which 56% is imported (most from Japan).** The rest is made in the U. S. by six manufacturers, three of which use trichlorobenzene and presumably have problems with PCB contamination. If the six manufacturers have equal market shares, the total PCBs in the production of the three that use trichlorobenzene would be (13.2 million pounds pigment per year x .44 U.S. market share x .5 share from companies with PCBs in product x 170 ppm PCBs =) 544 pounds PCBs per year.

Total annual sales of dairylide pigments are 9,760,000 pounds, all of which is contaminated with 3,3' - dichlorobiphenyl at an average concentration of 95 ppm. Reduction of this concentration to 50 ppm by required process changes would reduce the amount of PCBs entering the environment by (9,760,000 pounds pigment x (95 ppm - 50 ppm) =) 441 pounds per year.

Other chemicals: No information is available to support any estimate of the total production of PCBs in other chemical processes.

14.5 Summary - Economic Impacts

Upper Bound:

	Conversion Cost	Increased Annual Operating Costs	Additional Costs
Phthalocyanine pigments	$4,250,000	No data	No data
Diarylide pigments	1,330,000	345,000	No data
Aluminum smelting			
Chemical manufacturing	No data	No data	No data

*Appendix E to "Main Comments of Dry Color Manufacturers Association...." dated August 7, 1978.

**Letter from Arthur Hopmeier (Phthalchem Inc.) to EPA dated August 4, 1978.

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Lower Bound:

Exemption applications	$ 25,600		
Aluminum smelting			
Chemical manufacturing	No data	No data	No data

14.6 Cost Per Pound of PCBs Kept from the Environment

Phthalocyanine pigments: $\frac{\$425,000/*year}{544 \text{ pounds/year}}$ = $781 per pound PCBs

Diarylide pigments: $\frac{\$133,000^* + \$345,000/year}{441 \text{ pounds/year}}$ = $1084 per pound PCB

*Ten dollars as initial expense is equivalent to continuing annual costs of one dollar discounted at 10%.

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15.0 SPILL MATERIALS: 50 ppm TO 499 ppm PCBs

The change in the definition of "PCB" from 500 ppm to 50 ppm will require that materials such as dirt that are contaminated with PCBs in this concentration range will have to be picked up and buried in an approved PCB landfill. There is no information in the record that can be used to estimate the total additional volume of material that will be transported to these landfills as the result of this change in the regulation.

Disposal of PCB contaminated material in approved landfills has been reported to cost $3 per cubic foot (Versar 1977, p. 3-7) and transportation to these facilities will cost an additional $2 per cubic foot (Versar 1977, p. 3-19). If the spill material covered by this regulation is assumed to be contaminated with 275 ppm PCBs, the cost of disposal will be ($5 per cubic foot/(100 pounds per cubic foot of dirt x 275 ppm PCBs) =) $182 per pound of PCB. This figure could be lower in some cases if EPA approves alternative disposal methods in response to specific petitions for exemption from this portion of the disposal regulation.

MONS 013347

16.0 CAPACITOR MANUFACTURING

16.1 Present Use of PCBs

PCBs were used as the dielectric liquid in almost all paper/foil and film/foil A.C. electric capacitors manufactured prior to 1976. The primary types and uses of PCB capacitors are listed in Table 16.1-1.

Substitutes for PCBs have been developed by the capacitor manufacturers in anticipation of the ban on the manufacture and processing of PCBs. No PCB power factor capacitors were manufactured after late 1977, and there are no PCB capacitors of this type known to remain in manufacturers' inventories (Versar 1978, p. 99). A survey of manufacturers of industrial capacitors indicated that five companies (representing a 54% share of the market in 1976) were planning in mid 1977 to continue using PCBs into 1978 but to discontinue manufacturing PCB capacitors during 1978 (Versar, 1978, p. 103). Two of the manufacturers have provided additional data on their use of PCBs during 1978 and on expected inventories of PCB capacitors. Aerovox (24% market share) planned to stop using PCBs on September 9, 1978, and expected an inventory on October 1 of less than 100,000 PCB capacitors.* Universal Manufacturing Co. (13% market share) has estimated that its inventory of capacitors at the end of 1978 will be approximately 800,000 items which cost about one million dollars to manufacture. In addition, Universal will have an inventory at the end of 1978 of at least 500,000 completed ballasts which cost about $2,500,000 to make.**

*Letter from Clifford Tuttle (Aerovox Industries, Inc.) to EPA dated August 15, 1978.

**Oral comments of N. Ray Clark (Universal Manufacturing Corporation) at the August 29, 1978 hearing on the proposed PCB Ban Regulation.

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Table 16.1-1

Major Types and Uses of PCB Capacitors

Type	Estimate 1976 Sales*	Use*
Power Factor Correction	$54.5 million	Used by electrical utilities in high voltage power distribution systems.
Industrial Capacitors	$94.5 million	
Motor Control		Used as part of large single phase A.C. motors (air conditioners, etc.).
Ballast		Used as a component of ballasts for fluorescent lights and high intensity discharge (i.e., mercury arc and sodium arc) fixtures.
Electronic		As part of the circuitry in some TV sets, microwave ovens, computers, etc.

*Source: Versar, 1978, pp 97-98.

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16.2 Requirements of the PCB Ban Regulation

Manufacturing: The regulation bans the manufacture of PCB capacitors.

Distribution in Commerce: PCB capacitors and new equipment containing PCB capacitors may not be sold (i.e., distributed in commerce) after July 1, 1979.

16.3 Cost Impacts of the PCB Ban Regulation

Manufacturing ban: The economic impact analysis of the proposed PCB regulation estimated that non-PCB power factor capacitors would cost 10% to 20% more than PCB capacitors having the same performance characteristics and that the cost of industrial capacitors would increase 15% to 20% because of the change from PCBs to other dielectric fluids, (Versar, 1978). The only additional information that has since become available is the testimony of Ray Clark who suggested that "perhaps in the overall, simply based on the difference of dielectric constant (of the non-PCB dielectric fluid) the non-PCB industrial capacitors should cost more on the order of five to seven percent."* Based on 1976 industry sales (Table 16.1-1), annual cost increases due to the banning of the manufacture of PCB capacitors would be expected to be (10% to 20% of $54.5 million = $5.5 million to $11 million for power factor correction capacitors and (7% to 20% of $94.5 million =) $6.6 million to $18.9 million for industrial capacitors. These estimates should be increased by perhaps 15% to compensate for inflation during 1977 and 1978. Since the use of small capacitors is expected to grow rapidly over the next few years because of federally mandated improvements in the electrical efficiency of appliances, the total demand for capacitors and the total increased costs resulting from the ban on the use of PCBs may be greater than these estimates based on historical sales data.

*Oral comments of N. Ray Clark (Universal Manufacturing Corporation) at the August 29, 1978 hearings.

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Ban on Distribution in Commerce: The demand for PCB capacitors remaining in manufactures's inventories at the end of 1978 is likely to be extremely limited because the regulation bans the sale of these capacitors or new equipment containing PCB capacitors after June 30, 1979. The inventory losses incurred by the companies that use small capacitors in the manufacture of appliances and equipment is discussed in detail in Chapter 3.

The maximum inventory losses incurred by the manufacturers of PCB capacitors would occur if all capacitors remaining in inventory at the end of 1978 were scrapped. If all of the manufacturers who used PCBs in 1978 had the same expected inventory losses as that percentage of annual sales anticipated by Universal, total inventory losses would be (.54 market share for all affected capacitor manufacturers/.13 Universal market share) x $1,000,000 Universal inventory loss =) $4.15 million. However, the actual loss will probably be much less than this because Universal was the last company to phase out the use of PCBs and because some opportunities may exist during the first six months of 1979 to dispose of this inventory. Therefore a reasonable estimate of inventory losses may be in the range of $1 to $2 million, all occuring during 1979.

16.4 PCBs Controlled by the Regulation

Total consumption of PCBs by the capacitor manufacturing industry was 21 million pounds in 1975 of which 45% was used in large high voltage power factor capacitors and 55% in industrial, lighting, and appliance capacitors (Versar 1976a, p. 6).

Most large high voltage power factor capacitors do not rupture upon failure, and only 20% to 25% of the PCBs escape to the environment from those that do rupture. If it is assumed that 10% of the capacitors rupture on failure, the total amount of PCBs entering the environment from each year's production of large high voltage power factor capacitors would be equal to (21 million pounds per year PCBs x 45% in power factor capacitors x 1% rupture on failure x 15% PCBs lost on rupture =) 14,200 pounds PCB per year.

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Only 0.4% of the small capacitors are assumed to rupture in use (Chapter 3). If 15% of the PCBs leak out of these ruptured capacitors, the total amount of PCBs entering the environment from each year's production of small capacitors would be equal to (21 million pounds PCBs x 55% in small capacitors x 0.4% ruptured in use x 15% leak out =) 6930 pounds per year. The rest of the PCBs would be disposed of in municipal landfills. There is no information in the record to support an estimate of how much may leach out of the landfill, but it is expected to be low due to the absorptive capacity of the surrounding material.

16.5 Summary - Economic Impacts

Increased cost of non-PCB power factor capacitors: $5.5 million to $11 million per year.

Increased cost of non-PCB industrial capacitors: $6.6 million to $18.9 million per year.

Inventory losses incurred by manufacturers of PCB industrial capacitors: $1 million to $2 million (1979 only).

16.6 Cost Per Pound of PCBs Kept from the Environment

Power factor capacitors

$$\frac{\$5.5 \text{ million to } \$11 \text{ million per year}}{14{,}200 \text{ lb/year}} = \$387 \text{ to } \$775 \text{ per pound PCBs}$$

Industrial capacitors

$$\frac{6 \text{ million to } \$18.9 \text{ million per year}}{6930 \text{ pounds per year}} = \$950 \text{ to } \$2750 \text{ per pound}$$

MONS 013352

17.0 BAN ON THE MANUFACTURE OF NEW PCB TRANSFORMERS*

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 in hazardous locations such as inside buildings without the requirement for a fireproof vault or fire sprinklers. No substitute transformer liquids have yet been developed which have fire resistant properties equal to the PCB based askarel.

17.1 Requirements of the Regulations

The regulations prohibit the manufacture of new PCB transformers 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 authorize certain minor maintenance of existing transformers but prohibit major rebuilding of failed units. The impacts of the regulation on the servicing and rebuilding of askarel transformers is discussed in detail in Chapter 4. Disposal requirements for failed askarel transformers are specified by the PCB Marking and Disposal Regulations, and these requirements are not being changed by the PCB Ban Regulations.

17.2 Industry Structure, Production, and Sales

Monsanto's customer list for PCBs in the early 1970s included thirteen companies that used PCBs to manufacture askarel transformers. These companies and the location of their transformer manufacturing plants

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*This chapter is repeated with minor changes from Versar, 1978. The EPA promulgated without change the proposed regulations that affect the manufacture of new PCB transformers.

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are listed in Table 17.2-1. Production of askarel transformers averaged 5000 units per year in the early 1970s (Versar 1978, p.109). When these companies were contacted by Versar in September, 1977, only one manufacturer was still producing askarel transformers, and it planned to stop production of this type of unit before the end of 1977 (Versar 1978, p.109). All of these manufacturers produced both oil-filled and askarel transformers in the same plants. Oil-filled transformers are interchangable with askarel transformers in new applications provided the installation is properly engineered. Other substitutes for askarel transformers are also available. The 140,000 askarel transformers presently in service are only two percent of the total number of power and distribution transformers in use (Versar 1978, p.111).

17.3 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 optium use of the available non-PCBs transformers. The choice among the available alternative transformer types and materials depends on the requirements of each specific applicaiton and the characteristics of the available non-PCB units.

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Table 17.2-1

U.S. Transformer Manufacturers That 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, Mass.
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, 1976a.

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A number of alternatives to the use of PCBs in fire resistant liquid-filled transformers and to the use of transformers that 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 that are available.

Non-PCB askarel transformers: Askarels are defined in the National Electrical Code as non-flammable chlorinated hydrocarbon liquids. Although all askarel liquids used in the past have been based on PCBs, there is no requirement that PCBs be present. General Electric is presently testing a non-PCB askarel that is a combination of trichlorobenzene, tetrachlorobenzene, and a hydrocarbon (either isopropyl biphenyl or terphenyl). GE plans to market this material in 1979 under the trade name Iralec®, if present transformer service tests are successful, and estimates that the price will be about one-half that of silicone.*

If Iralec® does prove to be a direct substitute for PCB based askarel, there may be no additional costs incurred by the banning of the use of PCBs in new transformers.

High fire point liquid insulated transformers: The 1975 National Electric Code (NEC) and previous issues allowed only the use of askarel and dry type transformers in hazardous locations without vault protection. Askarel was essentially defined as a 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 (Versar 1978, p.111). The high fire point liquid must have a fire point of at least 300°C, and must not propagate flames.

*Information presented by GE at a meeting with EPA Office of Toxic Substances, June 21, 1978.

MONS 013356

Underwriters Laboratory presently lists three liquids as meeting the high fire point property requirements for transformers operating at voltages below 600v (Versar 1978, p.112):

Dow Corning 561

General Electric SF-97 (50)

SMS 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 which allow six silicone liquids and three hydrocarbon liquids at Factory Mutual insured locations without special fire protection. The list of Factory Mutual accepted liquids includes the following (Versar 1978, p.112):

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
SMS Silicones	F-101	Silicone
SMS Silicones	F-190	Silicone
RTE Corporation	RTEmp	Hydrocarbon
Gulf Oil Chemicals Co.	RF Dielectric Fluid	Hydrocarbon
Uniroyal	PAO-20E	Hydrocarbon

MONS 013357

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 (Versar 1978, p.112). 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 electric arc in mineral oil results in breakdown products that are non-corrosive.

The major disadvantage of mineral oil is flammability; transformer mineral oil has a flash point of 145°C. If an arc occurs in 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 that 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 trans-

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formers are located outside the building they service, the low-voltage power must be brought into the building via cables or insulated buses. Additional energy losses are then caused by 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, open air-cooled transformers are limited in both heat capacity (which limits their ability to operate under occasional overload conditions) and dielectric strength (which limits the maximum voltage available).

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 in the 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.

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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 (Versar 1978, p.115).

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 because of changes in gas pressure caused by changes in temperature. However, the maximum voltage ratings of gas-filled transformers can be equal to these 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 because any leak in the transformer would result in a severe fire hazard.

*This section is repeated from Versar 1978, pp.115-116.

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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.

17.4 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 17.4-1. 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 17.4-1*

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
Non-PCB askarel	19,000	29,000
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: MGC Engineers, "Distribution Transformer Status - WTI Project." Memorandum to U.S. General Services Administration, June 1, 1977, as cited in Versar 1978, p.116.

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17.5 Compliance Costs

Clean-up costs: The only costs incurred by transformer manufacturers resulting from the ban on the use of PCBs will be clean-up and disposal costs of flushing PCBs from storage and material handling equipment before 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 (Versar 1978, p.117).

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 non-PCB askarels and 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 sales and costs to the users by (5000 x $20,000 x 10% =) $10,000,000 per year. There should be no effect on the demand for transformers for new installations, and there may be an increase in the demand for replacement transformers of 1000 to 2000 units per year. This additional demand should be easily supplied since the transformer manufacturing industry has recently been operating at only about 60% of capacity (Versar 1978, p.117).

Market structure should not be significantly affected because 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 manufcturers 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 area. The increased sales by RTE will probably be less than the total increase in transformer sales, so this small shift in

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market structure should not result in a net decrease in the sales by any of the other manufacturers.

Increased fire losses: The presently installed PCB askarel transformers were installed at a premium cost compared to oil-filled units in order to achieve improved fire safety. Not all of the substitutes for PCBs have as good fire resistance. In particular, the high fire point transformer 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.

Various non-flammable substitutes for PCB askarel transformers are available, including the various dry type units and non-PCB askarels. Although these alternatives may cost more than the PCB units they replace, they can achieve equal fire safety. Therefore, the banning of the manufacture of PCB-filled transformers is not expected to result in significant increased fire losses.

17.6 PCBs Controlled by the Regulation

There is no information in the record to support any estimate of the probability that PCBs used in askarel transformers will enter the environment from accidental spills and venting of transformers. Venting results in the loss of no more than 2% of the total fluid in the transformer. However, good clean-up of spills should limit the total losses to perhaps 5% of the total liquid vented. Use of PCBs in transformer manufacturing was about 12 million pounds per year in 1975 (Versar 1976a, p.6). The ban on use of PCBs in new transformers will prevent the loss of (2% x 5% x 12 million pounds =) 12,000 pounds of PCBs into the environment from each year's production of transformers.

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17.7 Summary - Economic Impacts

Transitional Costs:

Clean-up costs for manufacturers	$100,000 1978 only.

Long Term Costs:

Higher costs of non-PCB transformers	$0 to $10 million per year.

17.8 Cost Per Pound of PCBs Kept From the Environment

$$\text{Cost per pound} = \frac{\$0 \text{ to } \$10 \text{ million per year}}{12{,}000 \text{ pounds per year}} =$$

$0 to $833 per pound PCBs

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18.0 SUMMARY

18.1 Transitional Cost Impacts

Costs of decontaminating or scrapping existing equipment and the ban on rebuilding of PCB transformers are all transitional costs. These costs will end when the existing PCBs are finally removed from service. The transitional cost impacts identified in this analysis of the impacts of the PCB Ban Regulation (as distinct from the previously promulgated PCB Effluent Standard and the PCB Disposal and Marking Regulations) are summarized in Table 18.1-1.

18.2 Long Term Cost Impacts

The costs resulting from the ban on the manufacture of PCBs will be continuing costs and will result in along term economic impact. These costs include the additional cost of non-PCB capacitors and transformers. The long term costs identified as resulting from the PCB Ban Regulation are summarized in Table 18.2-1.

18.3 Cost Per Pound of PCBs Kept from the Environment

The effectiveness of the regulation in preventing the entry of PCBs into the environment was calculated for each industrial segment if sufficient data was available. These costs are summarized in Table 18.3-1.

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Table 18.1-1

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 (17)	$ .1	0	$ .1	-50% + 500%
Ban on Rebuilding (4)	9.6	**	373 to 749	±50%
Lost Service Time	2.4	**	75	±50%
Locomotive Transformers (5)				
Retrofill Program to 6% Limit	Complete by Jan. 1, 1982		6.6	±20%
Retrofill Program to 0.1% Limit	Complete by Jan. 1, 1984		5.15	±20%
Analytical Costs	Complete by Jan. 1, 1985		.444	±50%
PCB Capacitors and Equipment				
Equipment Redesign (16)	*			
Manufacturers' Inventory Obsolescence (16)	1 to 2	0	1 to 2	±50%
Ban on Sales of Equipment after July 1, 1979 (3)	1,000	0	1,000	-100% + 50%
	These costs will be significantly reduced or eliminated if EPA grants exemptions from the "distribution in commerce" ban.			
Cost of Petitioning for Exemptions	10***	0	10	

*Data not available to support estimate; probably small cost impact.
**Costs will be incurred over 30 to 40 years, probably increasing slowly for 10 years and then decreasing slowly.
***May be significantly reduced if EPA accepts class action petitions.

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Table 10.1-1 (Continued)

Item (Chapter)	$ million Per Year 1979	Succeeding Yrs	$ million total	Estimated Reliability of Total
Oil Filled Transformers (6)				
Ban on Reclaiming Oil for Resale	3.2 to 5.6	3.2 to 5.6	? No data on duration of impact	
Cost of Equipping High Efficiency Boiler	No data	0		
Cost of Approved PCB Incineration	0 - 11.1	0 - 11.1	? No data on duration of impact	-90% to 0%
Transformer Service (7)				
Special Storage Areas	*	*	?No data on duration of impact	
Mining Machines (8)				
Rebuild Loaders	Complete by Dec 31, 1981		1.6	±20%
Scrap Continuous Miners	Complete by Dec 31, 1981		1 to 2.6	±50%
Storage Costs	.01	0	.01	±50%
Exemption of Application	.001	0	.001	±50%
Electromagnets (9)				
Ban on Rebuilding	.1	.1	.96	±20%
Hydraulic Systems (10)				
Testing	.5 to 1.4	1(1980-84 total)	1.5 to 2.4	±20%
Retrofill	9.8-16.1	1-1.5(1980 only)	10.8 to 17.6 by 1984	±50%
Disposal of Fluid 50-500 ppm PCBs	1.4	.2(1980 only)	1.6	-80% + 20%
Marking	.05	0	.05	±50%
Ban on Recycling Fluid	.3 to 1.7	0 to 1.7	.7 to 3.4	-80% + 20%

*Information Not Available in Record to Make Estimate.

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Table 18.1-1 (Continued)

Item (Chapter)	$ million Per Year 1979	$ million Per Year Succeeding Yrs	$ million total	Estimated Reliability of Total
Heat Transfer Systems (11)				
Testing	.045 to .06	.135 to .18	.18 to .24	±50%
Retrofill	5.1 to 6.8	9.9 to 13.2 (1980 only)	15 to 20 (by 1980)	±50%
Cost Savings - Disposal of Systems			(2.4 to 3.0)	±50%
Compressors (12)	.2	0	.2	-50% + 100%
Reclaimed Oil (13)				
Increased Cost of Synthetic Road Oil Material	0 to 31.7	0 to 31.7 (thru 1984)	0 to 100	
Increased Cost of Road Oil		0 to 6.4 (years 6-15)	0 to 64*	
Unintentional Contaminants (14)				
Process Changes - Phthalocyanine Pigments	4.25	0	4.25	-80% + 50%
Process Changes - Diarylide Yellow Pigments	1.3	0***	1.3***	-80% + 50%
Process Changes - Other Processes	**	0	**	
Exemption Applications	.02	0	.02	-80% + 50%

*Costs to continue indefinitely until waste industrial oil no longer contains measurable amounts of PCBs.
**Information not available in the record to make estimate.
***Also long term cost impacts: See Table 18.2-1.

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Table 18.2-1

Long Term Cost Impacts

Transformers: (Chapter 17)	
Increased Cost of Non-PCB Transformers	$0 to 10 million/year
Increased Fire Losses	$0
Capacitors: (Chapter 16)	
Increased Cost of Non-PCB Power Factor Capacitors	$5.5 to 11 million/year
Increased Cost of Non-PCB Industrial Capacitors	$6.6 to 18.9 million/year
Diarylide Yellow Pigment (Chapter 14)	
Increased Manufacturing Cost	$345,000/year
Spill Materials (50 to 500 ppm PCBs) (Chapter 15)	No data

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Table 18.3-1 Economic Costs of the PCB Ban Regulation

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

*Information not available in record to make estimate.

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

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Table 18.3-1 (Continued)

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

*Information not available in the record to make estimate.

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15. Supplementary Notes

EPA Project Officer: Mr. Stephen Weil

16. Abstracts

This report summarizes the estimated economic impacts of PCB Ban Regulations which implement the requirements of Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act.

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

Polychlorinated Biphenyls
Toxic Substances Control Act
Liquid Waste Disposal
Economic Analysis
Public Utilities
Capacitors
Transformers
Coal Mining
Waste Oils

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 173
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Support Document/Voluntary Environmental Impact Statement
and
PCB Manufacturing, Processing, Distribution in Commerce,
and Use Ban Regulation: Economic Impact Analysis

EPA

MONS 013378

EPA 230-03/79-001

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

ECONOMIC IMPACT ANALYSIS



MARCH 1979

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PLANNING AND MANAGEMENT
WASHINGTON, D.C. 20460

MONS 013200

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

MONS 013201

EPA 230-03/79-001

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

ECONOMIC IMPACT ANALYSIS

Final Report

Submitted to:

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

Attention: Mr. Stephen R. Weil
Project Officer

Contract No. 68-01-4771

March 30, 1979

MONS 013202

This report has been reviewed by the Office of Planning and Management, U.S. Environmental Protection Agency, and approved for publication. Approval does not necessarily signify that the contents reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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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 PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation - 40 CFR Part 761. This regulation implements the requirements of Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act.

Versar's analysis of the economic impacts of the proposed PCB Ban Regulation was summarized in the report "Microeconomic Impacts of the Proposed 'PCB Ban Regulations'" dated May 16, 1978. The promulgated regulations incorporate a significant number of changes that were made to the proposed regulations. In addition, considerable additional information on the economic impacts of the regulation has been added to the rulemaking record as the result of written comments on the proposed regulation and two weeks of public hearings. This report is a revision of the report on the proposed regulations and is based on the promulgated regulations and the information available from the rulemaking record.

This revised report was prepared by Mr. Robert A. Westin, Principal Investigator, and Mr. Bruce Woodcock. Assistance in the handling of data and the preparation of final copy was provided by Ms. Juliet Ballance and Mrs. Rebecca Brown of the Versar staff. Special acknowledgement is given to the close support received from Mr. Stephen R. Weil, EPA Project Officer, and Mr. Steven B. Malkanson who was the EPA Project Officer during the preparation of early drafts of this report.

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1.0 INTRODUCTION

1.1 History of PCB Use

Commercial PCBs are manufactured by the direct chlorination of the chemical "biphenyl." The result of this reaction is a mixture of chlorinated biphenyl molecules that differ in the number and arrangement of chlorine atoms attached to the biphenyl rings. The final product may contain between 21% and 68% chlorine by weight, depending on the amount of chlorine introduced to the reaction vessel. PCBs, therefore, are mixtures of various kinds of polychlorinated biphenyls.

The first commercial production of PCBs in the United States was in 1929. Almost all of the PCBs that have been produced in the U.S. were manufactured by Monsanto Industrial Chemicals Company which marketed various mixtures under the trade names Aroclor® 1016 and Aroclor® 12xx, with the last two digits denoting the average percent chlorine in the mixture. The commercial PCBs varied from Aroclor® 1221 (similar in physical properties to a light oil) to Aroclor® 1268 (a waxy solid). Monsanto also used PCBs in some commercial products formulated for specific purposes, including certain types of Pydraul® hydraulic fluids, Therminol® heat transfer fluids, Turbinol® compressor fluids, and Santovac® vacuum pump fluids. In addition, Monsanto produced various mixtures of polychlorinated terphenyls (PCTs), all of which contained up to 1% PCBs as unintentional byproducts. The PCTs were marketed under the trade name Aroclor® 54xx, with the final digits again denoting the average chlorine content. The PCTs were also marketed as constituents of some Pydraul® hydraulic fluids (Versar, 1976a).*

PCBs in general were noted for their excellent chemical stability, low solubility in water, and low price. The various commercial

*Versar, Inc., 1976a. PCBs in the United States: Industrial Use and Environmental Distribution, Springfield, Va.: National Technical Information Service (NTIS PB 252-012/3WP), February, 1976.

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mixtures covered a wide range of viscosities, melting points, and boiling points and were used in a number of applications including as a plasticizer for plastics, paints, and caulking compounds; as a dielectric liquid in electrical transformers, motors, electromagnets, and capacitors; as a dye carrier in certain carbonless copy papers and printing inks; and as an additive to certain greases, lubricating oils, casting waxes, hydraulic fluids, heat transfer liquids, compressor liquids, and vacuum pump liquids. The various uses of PCBs were described in a report published in early 1976 (Versar, 1976a); estimated use of PCBs in each application and the present environmental distribution of the PCBs are summarized in Table 1.1-1.

PCBs were not generally recognized as being toxic until after the occurrence in 1968 of widespread poisoning in Japan caused by the accidental introduction of PCBs into cooking oil. The resulting acute symptoms became known as "Yusho" disease, and it affected 1291 people*. In 1969, analytical procedures were developed that enabled PCBs to be identified in concentrations of parts per million in environmental samples. In 1970, PCBs were identified as the contaminant in coho salmon from Lake Michigan that had affected the reproduction rate of commercial mink fed contaminated fish. The mink reproductive problems had first been reported in 1965; identification of PCBs as the cause awaited development of satisfactory analytical procedures (Stendell, 1975).**

*For a comprehensive review and discussion of the literature describing the toxicity of PCBs and the details of the YUSHO incident, see: NIOSH, Criteria for a Recommended Standard....Occupational Exposure to Polychlorinated Biphenyls (PCBs), Washington, D.C.: U.S. Government Printing Office, 1977, pp.40-49.

**Stendell, Ray C. 1975. "Summary of Recent Information Regarding Effects of PCB's on Birds and Mammals" in Conference Proceedings, National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Illinois. Washington, D.C.: Office of Toxic Substances, U.S. Environmental Protection Agency (Report No. EPA-560/6-75-004).

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In 1972, Monsanto voluntarily restricted the sale of PCBs to the manufacture and maintenance of electrical transformers and capacitors and introduced the product Aroclor® 1016 as a more biodegradable dielectric liquid for use in capacitors (Wood, 1975).* Monsanto then contacted their customers to recommend that heat transfer systems containing PCB based Therminol® fluids be drained, flushed, and refilled with non-PCB liquids and that hydraulic systems containing PCB based Pydraul® fluids be topped off as required with compatible non-PCB liquids (Versar, 1978, p. 75).**

Following Monsanto's action in 1972, the only U.S. production of PCBs for "open" system use was by Geneva Industries which manufactured about one million pounds of PCB based heat transfer liquid between 1972 and 1974 (Versar, 1978, p. 4). PCBs were also imported after 1972 for use in maintaining electric motors in certain coal mining machines, and for use in some types of investment casting waxes.

1.2 Regulatory Action on PCBs

In 1973, the U.S. Food and Drug Administration (FDA) established temporary tolerances for PCBs in food, and FDA surveillance resulted in the rejection of numerous lots of fish and occasional lots of chickens and eggs (FDA, 1973).*** By 1975, there was significant evidence of PCBs in industrial effluents and in the environment, and reports of PCB contamination were being featured in the non-technical press. On March 26,

*Wood, David (Monsanto). 1975. "Chlorinated Biphenyl Dielectrics, Their Utility and Potential Substitutes" in Conference Proceedings, National Conference on Polychlorinated Biphenyls, November 19-21, 1975, Chicago, Illinois Washington, D. C. : Office of Toxic Substances, U.S. Environmental Protection Agency (Report No. EPA-560/6-75-004) pp. 317-322.

**Versar, Inc. 1978. Microeconomic Impacts of the Proposed 'PCB Ban Regulations' (EPA 560/6-77-035), Springfield, Va.: National Technical Information Service (NTIS PB 281-881/3WP). May, 1978.

***FDA. 1973. "Polychlorinated Biphenyls - Contamination of Animal Feeds, Foods, and Food Packaging Materials," Federal Register, July 6, 1973, pp. 18096-18103.

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1976, Senator Gaylord Nelson of Wisconsin introduced into the Senate an amendment to the Toxic Substances Control Act (TSCA) that required the eventual elimination of the use of PCBs in the United States. This amendment was the basis of Section 6(e) of TSCA (Figure 1.2-1), and the eventual ban on the manufacture of PCBs became a legislated requirement on October 11, 1976, when TSCA was signed into law.

Concurrent with the consideration of the PCB amendment to TSCA, the EPA proposed toxic pollutant effluent standards for PCBs under Section 307(a) of the Federal Water Pollution Control Act (EPA, 1976).* This proposed regulation would have imposed severe limitations on PCB discharges by capacitor and transformer manufacturers who used PCBs. Following extensive hearings, the PCB effluent standard was promulgated on February 2, 1977 (EPA, 1977d).** The regulation required that all PCB manufacturers and those transformer manufacturers and capacitor manufacturers using PCBs eliminate PCBs from their effluent water by February 2, 1978. The one-year compliance deadline for manufacturers of electrical equipment was established to enable plants to phase out the use of PCBs, convert to substitutes, make appropriate technological or process changes, or take such other steps as necessary to achieve compliance.

Section 6(e) of the Toxic Substances Control Act (TSCA) required the EPA to regulate the marking and disposal of existing PCBs. The manufacture of PCBs and their handling and use in other than a totally enclosed manner was banned effective January 1, 1978. The act also completely banned the manufacture of PCBs after January 1, 1979, and their distribution in commerce effective July 1, 1979. Finally, the act authorized the EPA to grant exemptions and authorizations under certain conditions.

*EPA. 1976. "Water Program - Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls," Federal Register, July 23, 1976, pp. 30468-30477.

**EPA. 1977d. "Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls (PCBs): Final Decision," Federal Register, February 2, 1977, pp. 6531-6555.

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Figure 1.2-1

Section 6(e), Toxic Substances Control Act

Rules.

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

(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.

"Totally enclosed manner."

(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.

(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.

Petition for exemption.

(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—

(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.

Terms and conditions.

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.

(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.

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Regulatory implementation of the various requirements of Section 6(e) of TSCA has occurred in several steps. EPA proposed regulations on the marking and disposal of PCBs on May 24, 1977 (EPA, 1977a),* and made available a support document (EPA, 1977c)** and a contractor's report on the estimated economic impacts of the proposed regulations (Versar, 1977).*** Written comments on the proposed rule were accepted by the EPA and informal hearings were held during the period June 24-29, 1977. The final regulations were promulgated on February 17, 1978 (EPA, 1978a),**** and corrections were published on August 2, 1978 (EPA, 1978b).*****

The EPA held public meetings on the remaining use ban provisions of Section 6(e) on July 15, 1977, in Washington, D.C., and on July 19, 1977, in Chicago, Illinois. On December 30, 1977, the EPA announced that it would not implement the ban on activities conducted in other than a totally enclosed manner (Section 6(e)(2)) until after formal regulations were promulgated (EPA, 1977b).****** These use ban regulations were proposed on June 7, 1978 (EPA, 1978e).******* At the same time, the EPA

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*EPA 1977a. "Polychlorinated Biphenyls (PCBs), Toxic Substance Control," Federal Register. May 24, 1977, pp. 26564-26577.

**EPA. 1977c. PCB Marking and Disposal Regulations - Support Document, (OTS-068005) Washington, D.C.: Office of Toxic Substances, U.S. Environmental Protection Agency, undated.

***Versar, Inc. 1977. Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs (EPA 560/67-77-013), Springfield, Virginia: National Technical Information Service, (NTIS PB 267-833/2WP), April, 1977.

****EPA. 1978a. "Polychlorinated Biphenyls (PCBs), Disposal and Marking." Federal Register. February 17, 1978, pp. 7150-7164.

*****EPA. 1978b. "Polychlorinated Biphenyls (PCB's), Addendum to Preamble and Corrections to Final Rule." Federal Register. August 2, 1978, pp. 33918-33920.

******EPA. 1977b. "Polychlorinated Biphenyls (PCBs), Toxic Substance Control." Federal Register. December 30, 1977, p. 65264.

*******EPA. 1978e. "Polychlorinated Biphenyls (PCB's), Manufacturing, Processing, Distribution in Commerce, and Use Bans," Federal Register, June 7, 1978, pp. 24802-24817.

MONS 013218

made available a support document (EPA, 1978c)* and a contractor's report on the estimated economic impacts (Versar, 1978). In the preamble to the proposed regulation, the EPA asked for written comments on specific technical aspects of the regulation. Written comments were accepted until the start of the hearings which were held in Washington, D.C., from August 21 through September 1, 1978. Opportunity for cross examination of the EPA economics contractor was granted to the Edison Electric Institute and the Electronic Industries Association on September 26, 1978, and reply comments on the proposed regulation were accepted for one week after that date.

Versar's previous report on the economic impact of the PCB Ban Regulations (Versar, 1978) was based on the proposed regulations and the data available in May 1978. EPA has since considered several hundred written main comments and reply comments and the information presented at ten days of informal hearings and has revised many of the details of the proposed regulations. The information presented to the EPA since the regulations were proposed has also significantly augmented the data available to Versar. The purpose of this report is to revise the economic analysis performed in May, 1978, to reflect the changes in the regulation and to incorporate additional information (1) that has been made available to the EPA as a result of the rulemaking, and (2) that has been included in the rulemaking record.

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*EPA. 1978c. Office of Toxic Substances. Support Document/Draft Voluntary Environmental Impact Statement for Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation (Section 6(e) of TSCA). Washington, D.C.: U.S. Environmental Protection Agency. May 1978.

MONS 013219

2.0 METHODOLOGY FOR ECONOMIC IMPACT ANALYSIS OF THE PCB BAN REGULATIONS

2.1 General Approach

Section 6(e) of the Toxic Substances Control Act (TSCA) established specific dates for the banning of activities involving the manufacture, processing, distribution in commerce, and use of PCBs. TSCA also authorized the EPA to grant exemptions from the rule or to authorize specific activities that would otherwise be banned. These exemptions and authorizations may be granted only if the EPA makes a formal finding that the activities "do not present an unreasonable risk of injury to health or the environment."

If the EPA had not promulgated the PCB ban regulations, the requirements of TSCA could have taken full effect on the dates specified in the act. The effect of the discretionary actions that the EPA has taken by promulgating the regulations is to reduce the economic impact of the legislated requirements in certain cases.

Since the EPA defined in the regulation those materials and manufactured products that are subject to the legislated requirements, it is difficult to separate the economic consequences of the act from the economic impact of the regulation. Calculation of total economic impacts is further complicated by the compliance actions taken by industry in anticipation of the regulations.

This analysis is limited to impacts expected to result from the PCB ban regulations. These 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 by the PCB Disposal and Marking Regulations. Increased industry costs caused by 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. Each affected

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industry is considered separately, and long-term economic impacts are calculated by predicting long-term practices and comparing the resulting costs to those that would have been incurred under the base period conditions. Transitional costs are also calculated where there will be a significant capital investment required to comply with the ban regulations or where there will be a prolonged period of adjustment of industrial practices. The economic impact analysis is limited to directly affected industries and to their suppliers and customers. The analysis does not evaluate (1) minor secondary impacts and ripple effects of the regulations, (2) benefits to health or the environment from the ban, or (3) the extent to which exemptions that may be granted by the EPA will reduce these costs.

In general, the methodology used to estimate the economic impacts of the PCB Ban Regulations is the same as that used in previously published studies of the economic impacts of the Proposed PCB Ban Regulations (Versar, 1978), of the Proposed PCB Marking and Disposal Regulations (Versar, 1977), and of the Proposed PCB Effluent Standards (Jack Faucett Associates, 1976).* All of the cited economic impact studies, including this one, have been limited to an evaluation of the costs of the regulations.

*Jack Faucett Associates, Inc. 1976. Economic Analysis of Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls: Transformer, Capacitor, and PCB Manufacturers (EPA 230/1-76-008), Washington, D.C.: Office of Water Planning and Standards, U.S. Environmental Protection Agency. October 1976.

MONS 013221

2.2 Data Base for Economic Impact Analysis

This report's analysis of the economic impacts of the final PCB Ban Regulations is based on the following data:

- Published reports as referenced in the Official Record of rulemaking including the previous Versar report "Microeconomic Impacts of the Proposed 'PCB Ban Regulations'" (Versar, 1978).
- Written comments on the Proposed PCB Ban Regulations received by EPA and made part of the official record of rulemaking.
- Oral comments presented at the public hearings on the proposed rule (August 21 through September 1, 1979). Verbatim transcripts of these hearings are part of the official record of rulemaking.
- Reply comments on the proposed rule received by EPA subsequent to August 21, 1979, and made part of the official record.
- Information on the sampling protocols used by utilities in selecting oil filled transformers to be tested for the presence of PCBs. This information was obtained by Versar through phone conversations with representatives of companies that presented data on the extent of PCB contamination of transformer oil in their written or oral comments on the proposed regulation.

MONS 013222

3.0 IMPACT OF BAN ON THE DISTRIBUTION OF PCB CAPACITORS AND EQUIPMENT

3.1 Present Status

3.1.1 PCB Capacitors

The use of PCBs in small capacitors has been gradually phased out over the past two years. Although several manufacturers were using PCBs in at least a portion of their 1978 production of small capacitors, most capacitors manufactured during 1978 do not use PCBs. Most small capacitors are used in the manufacture of new appliances and lighting fixtures; the use of capacitors as repair parts accounts for a comparatively small percentage of the total demand for these items.

Emerson Quiet Kool Company estimated that it would have an inventory of approximately 30,000 PCB capacitors as of January 1, 1979, and that this inventory would represent an investment of $120,000.* Advance Transformer estimated that they might have 100,000 PCB capacitors in inventory on January 1, 1979, that were not built into ballasts or other equipment.** It is not possible to extrapolate this data to an estimate of the total inventories of capacitors that may remain unused on July 1, 1979. If each company normally carries a two-month inventory of capacitors and if only ten percent of these contained PCBs on January 1, the value of small PCB capacitors in the inventory of equipment manufacturers would have been one sixtieth of annual capacitor sales of $95 million, or approximately $1.5 million on January 1, 1979. The number of PCB capacitors remaining in inventory on July 1, 1979, will probably depend on the policies of various companies regarding the maintenance of spare parts for obsolete equipment. There will apparently be sufficient time available for manufacturers to use their inventories of PCB capacitors that are components of presently manufactured products.

*Letter from George Hakin (Emerson Quiet Kool Company) to EPA, dated August 2, 1978.

**Oral comments of Ernest Freegard (Advance Transformer Company) at the Hearings on the PCB Ban Regulation, August 23, 1978.

MONS 013223

3.1.2 PCB Equipment

Most capacitors used in appliances and lighting fixtures manufactured during 1978 do not contain PCBs. There is no easy way to distinguish which appliances do contain PCB capacitors. The provisions of the PCB Disposal and Marking Regulations that require that non-PCB capacitors and non-PCB fluorescent light ballasts be distinguishable from PCB units did not become effective until July 1, 1978 (EPA, 1978a). The regulations that require equipment containing PCB capacitors be so marked apply only to equipment manufactured after December 31, 1978 (EPA, 1978b).

There are also considerable numbers of PCB capacitors presently in inventory in electrical subassemblies such as fluorescent light ballasts. According to Mr. Ray Clark, the manufacturers of fluorescent light fixtures normally carry a 60-day supply of ballasts in inventory, and he estimated that about one million of the seven million ballasts in their inventories on January 1, 1979, would contain PCB capacitors.* Not all of these ballasts are used within sixty days. Manufacturers of lighting fixtures also maintain inventories of the less common and obsolete ballasts for use as replacement parts in existing fixtures. Some of these ballasts may remain in inventory for as long as thirty years.** According to Mr. Freegard, the percentage of production of ballasts by Advance Transformer Company that involves the slow moving types is less than ten percent of the fluorescent light ballasts and perhaps slightly more than ten percent of the ballasts for high intensity discharge (mercury arc and sodium arc) lighting ballasts.***

*Oral comments of N. Ray Clark (Universal Manufacturing Corporation) at the hearings on the PCB Ban Regulation, August 28, 1978.

**Oral comments of Herbert Rowe (Electronic Industries Association) at the hearings on the PCB Ban Regulation, August 23, 1978.

***Oral comments of Ernest Freegard (Advance Transformer Company) at the hearings on the PCB Ban Regulation, August 23, 1978.

MONS 013224

Electrical equipment containing PCB capacitors may pass through several hands prior to its sale to the final consumer. For instance, air conditioning units are distributed by the manufacturer to retailers under a conditional sales agreement which allows the units to be returned to the manufacturer if they are not sold during the summer season. The unsold units are then stored during the winter and sent to retailers the following spring. Amana Refrigeration stated that "There is customarily a large amount of carry-over merchandise left over in the distribution channel after the primary selling season has ended. It is not uncommon for a dealer or distributor to have an inventory containing air conditioning equipment which is three to four years old."*

Microwave ovens do not have the seasonal sales pattern of air conditioning units, but inventory carry-over is still significant. Mr. Weisserick of the Association of Home Appliance Manufacturers calculated the rate of sales of each year's production to be 54% per year based on a total durable goods inventory equal to 72% of annual shipments. Carry-over from the production years 1975 through 1977 would therefore be expected to be 239,000 units on December 31, 1978, and 120,000 units on June 1, 1979.** Inventories of lighting ballasts and fixtures might be expected to turn over more rapidly. However, many of these items are manufactured as components of equipment such as subway cars and highway luminaries which will be classified as PCB equipment and which have longer lead times prior to final sale to the user.

*"Comments of Amana Refrigeration, Inc. ...." submitted to EPA as an attachment to a letter dated August 4, 1978, from Arthur Herold of Webster and Chamberlain.

**Letter from J.T. Weisserick (Association of Home Appliance Manufacturers) to Steven Rosenthal (Covington and Burling) dated September 7, 1978 (Appendix III). This letter was submitted to the EPA as an attachment to a letter from Mr. Rosenthal dated September 12, 1978.

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The manufacture of appliances using PCB capacitors is not banned until July 1, 1979, but any such appliances manufactured during 1979 must have the PCB equipment label applied. Therefore, it will be easier to identify equipment containing PCB capacitors that was manufactured during 1979 than that manufactured in 1977 and 1978.

3.2 Requirements of the Regulation

Sale of new PCB capacitors: The sale of new PCB capacitors is banned after June 30, 1979, unless EPA grants a specific exemption from this "distribution in commerce" ban requirement.

Manufacture of PCB equipment: The use of PCB capacitors in the manufacture of new equipment such as television sets, microwave ovens, and fluorescent light ballasts and fixtures is considered a totally enclosed processing of PCBs. Since all processing is banned after June 30, 1979, PCB capacitors and subassemblies containing PCB capacitors will have to be used by June 30 unless a petition for an exemption from this processing ban requirement is granted by the EPA.

Sale of new PCB equipment: The sale of new PCB equipment is banned after June 30, 1979, unless EPA grants a specific exemption from this "distribution in commerce" ban requirement.

Exemption requirements: EPA has not yet stated the conditions under which petitions for exemptions from these ban provisions will be accepted or the conditions under which exemptions will be granted except to state that any exemptions granted will be for a period of only one year. EPA has suggested that exemptions may be granted only under those conditions (1) that will result in no significant threat to health or the environment and (2) where a good faith effort to develop substitutes for the PCB capacitors has been demonstrated.

3.3 Economic Impact of the Regulation

3.3.1 PCB Capacitors

The regulation bans the distribution in commerce after July 1, 1979, of PCB capacitors unless the EPA grants exemptions from this

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requirement. If the EPA grants a complete exemption from this requirement, there could be zero economic impact. If the EPA does not grant any exemptions, the effect of the regulation would be to require that all small PCB capacitors be sold to the ultimate users by July 1, 1979, and that any PCB capacitors remaining in the distribution channels at that time be disposed of in accordance with the disposal requirements.

The economic impacts resulting from the ban on "distribution in commerce" will depend on the extent to which EPA grants exemptions. The number of individual small capacitors maintained in inventory as spare parts is not known but is probably no more than a few percent of one year's production of PCBs. Many of these capacitors might be relatively old, having been left over from production runs of unusual types and then kept as spares to replace units that fail in service. A rough estimate of the value of small capacitors remaining in inventory on July 1, 1979, would be that the parts inventory would equal two percent of annual production of small capacitors and that one half of these might still be PCBs. The value of small industrial capacitors was previously reported to be $94.5 million in 1976 (Versar, 1978, pp. 97-98). The manufactured cost of remaining inventories of PCB capacitors would therefore be (2% x 1/2 PCBs x $94.5 million=) $1 million. The economic loss resulting from a ban on the sale of these capacitors might be larger than this amount if equipment that is otherwise usable must be scrapped because no replacement capacitors are available. However, no information is available to support an estimate of the resulting costs.

It is anticipated that additional information will be made available to EPA in petitions for exemptions from the ban on sale of capacitors. This information will enable EPA to more accurately estimate economic impacts of their decisions on the exemption petitions.

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3.3.2 PCB Equipment

Compliance with this regulation would require that all inventories of subassemblies, appliances, and lighting fixtures containing capacitors on July 1, 1979, be examined to determine whether any of the capacitors contain PCBs. Any PCB capacitors that are found will have to be replaced with non-PCB capacitors before the subassembly, appliance, or lighting fixture can be sold.

A ban on the distribution in commerce of equipment containing PCB capacitors will have a greater impact than a ban on the sale of capacitors because the equipment ban will involve more items and because it will be more difficult to identify the banned items. The major cost of the regulation would result from the efforts to identify which equipment contains the PCB capacitors so that they could be replaced with non-PCB units.

A rough estimate of the total number of items in inventory that will have to be checked to determine whether they contain PCB capacitors can be calculated from information presented by the industry. Aerovox reportedly has about 24% of the market for small industrial capacitors (Versar, 1978, p. 103) and has stated that their production rate is 80,000 units per day.* If the average unit cost of Aerovox production is representative of the industry, this would imply an annual production of (80,000 units per day x 250 days/0.24 market share=) 83.3 million capacitors per year. The average cost would therefore be ($94.5 million/83.3 million units) = $1.13 per capacitor. If dealer inventories equal 70% of annual shipments, this implies that there will be (83.3 million units per year x .7 =) 58.3 million separate pieces of equipment containing small capacitors in inventory at any given time.

The inventory model suggested by Mr. Weizeorick can be modified to calculate the fraction of units in inventory on July 1, 1979, that will

*Letter from Clifford H. Tuttle (Aerovox Industries, Inc.) to EPA dated August 15, 1978.

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contain PCB capacitors. This model assumes that production of capacitors is constant at P_o units per year, that the ratio of inventory to sales is equal to 0.71, and that the probability of sale of any given item is not proportional to the time it has been in inventory. Mr. Weizeorick stated the relationship between inventory, production, and sales by the differential equation

$$\frac{di}{dt} = P-S$$

where i = inventory at time t
P = production rate, units per year
S = sales rate, units per year

and solved this equation for the condition

$t < 0$, $P = 0$
$t > 1$, $P = 0$
$0 \leq t \leq 1$, $P = P$

However, starting at about the beginning of 1977, some of the production of capacitors was of non-PCB units, and by the end of 1978, all of the capacitors being produced were non-PCB types. If it is assumed that the proportion of PCB capacitors used by equipment manufacturers decreased linearly from 100% PCB on January 1, 1977, to 0% on December 31, 1978, the production rate of equipment containing PCB capacitors during these two years could be expressed by the equation:

$$P = P_o\ (1 - \frac{t}{2}),\ t = 0 \text{ to } 2$$

where P_o = constant production rate using all capacitors
P = production rate using PCB capacitors
t = years after January 1, 1977.

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The differential equation for the inventory of PCB items during these two years would then be expressed as

$$\frac{di}{dt} = P - S \tag{1}$$

and since:

$$S = \frac{i}{.71} \tag{3}$$

$$\text{and } P = P_o \left(1 - \frac{t}{2}\right), \tag{2}$$

$$\text{then } \frac{di}{dt} = P_o \left(1 - \frac{t}{2}\right) - \frac{i}{.71} \text{ from } t = 0 \text{ to } t = 2 \tag{4}$$

In linear form, this equation can be written:

$$di + \left[\frac{i}{.71} - P_o \left(1 - \frac{t}{2}\right)\right] dt = 0 \tag{5}$$

which has the solution

$$i = .71\ P_o \left[1 - \frac{t}{2} + \frac{.71}{2} \left(1 - e^{-t/.71}\right)\right] \tag{6}$$

where $i = .71\ P_o$ at $t = 0$

Evaluating for the inventory at the end of 1978 (i.e., $t = 2$), $i = .334$, or 33.4% of equipment in inventory on January 1, 1979, contained PCB capacitors.

Assuming that no PCB equipment was made after January 1, 1979, the differential equation for the inventory would be written

$$\frac{di}{dt} = - S \tag{7}$$

Since $S = \frac{i}{.71}$, this can be written as

$$di + \frac{i}{.71} dt = 0 \tag{8}$$

which has the solution

$$i = i_o e^{-\frac{t}{.71}} \text{ for } i = i_o \text{ at } t = 0 \tag{9}$$

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On July 1, 1979, (t = 1/2), the inventory of PCB items, will therefore be equal to .49 of the initial inventory at the beginning of the year, or equal to (.49 x .334 x P =) 16.4% of the total inventory.

Based on these calculations, the inventory of equipment containing capacitors on July 1, 1979, will consist of 58.3 million items, of which 9.56 million will contain PCB capacitors. These capacitors will have an estimated manufacturers' sales price of (9.56 million capacitors at $1.13 =) $10.85 millon. These estimates will be higher than the actual inventory of PCB capacitors to the extent that dealers succeed in selling their oldest stock first.

If the EPA does not grant exemptions from the ban on the sale of equipment containing PCB capacitors, the dealers may have to open many of the 58.3 million items to determine which items contain PCB capacitors, and then replace the capacitors in 9.56 million items with non-PCB capacitors. Major cost items for the inspection program will be labor, customer discounts required to offset the damage to the packing cartons, and supervision. In most instances, the equipment will have to be partially disassembled in order to expose the capacitor. Mr. Weizeorick suggested a cost of $40 per unit based on $20 labor, $10 administrative cost, and $10 reduced value caused by damage. This implies a total program cost of $2.33 billion to inspect all 58.3 million items. It is possible that at least some of the units could be identified as not containing PCB capacitors by checking each unit serial numbering and information supplied by the manufacturer. However, even if the labor and administrative expenses could be cut by a factor of three to an average of $10 per unit by identifying serial numbers and therefore not having to disassemble the units, the inspection program would still cost in excess of $1 billion.

The second portion of this program will consist of replacing the capacitors in the 9.56 million pieces of equipment that are found to contain PCB capacitors. Mr. Weizeorick suggested a rework cost of $75 per unit implying a total cost of $717 million. This is undoubtedly high, since many of the suspect items are fluorescent light fixtures that retail for about $10 per unit. There is not sufficient information to estimate

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the proportion of the 58.3 million units in inventory that would be sold at distress prices before July 1, 1979, or scrapped rather than being inspected. However, it must be concluded that the total inspection costs, rework costs, and losses due to forced sales could easily exceed $1 billion.

The calculated costs resulting from the ban on distribution in commerce of equipment containing PCB capacitors is admittedly based on a number of assumptions. However, it is anticipated that additional information on the economic impacts will be presented to the EPA by the manufacturers and distributors of this equipment together with their petitions for exemptions from these requirements.

The final cost impact of these regulations will result from the requirement that impacted manufacturers and distributors of PCB equipment apply for exemptions. These petitions will require that detailed cost estimates be prepared which in turn will require the participation of corporate marketing, accounting, and legal staff. Each petition would likely require anywhere from 3 to 30 man days of effort to prepare, and cost a total of $1,000 to $10,000 based on total burdened labor at $42 per hour. EPA has not yet announced its policy on accepting class action petitions. If each manufacturer and retailer is required to apply separately, perhaps 1,000 to 10,000 petitions will be filed, at a total cost of about $10 million.

3.4 PCBs Controlled by the Regulation

Total consumption of PCBs by the capacitor manufacturing industry during 1975 was about 21 million pounds, of which 55% was used in small industrial and appliance capacitors (Versar 1976a, p. 6). If total production of these small capacitors was 83.3 million units, the average capacitor contained (21 million x .55/83.3 million =) 0.14 pounds of PCBs.

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The ban on the sales of spare capacitors would affect $1 million worth of capacitors containing a total of ($1 million x 0.14 lb PCB per unit/$1.13 per unit =) 124,000 lb PCBs. The capacitors removed from equipment in inventory would contain (9.56 million units x 0.14 lb PCB per unit =) 1,340,000 lb PCBs.

It is assumed that the spare capacitors are still owned by manufacturers of PCB equipment and will have to be disposed of in approved chemical waste landfills. The capacitors in equipment are assumed to be in dealers inventories, and these may be disposed of in municipal trash.

The failure rate of small capacitors is about 0.2% per year, of which 10% leak on failure.* If the average appliance lasts twenty years, each capacitor would have a (20 years x 0.2% probability of failure per year =) 4% probability of failure.

The effect of the regulation will be to prevent the loss of PCBs to the environment by capacitors that fail and leak in service. If it is assumed that all the PCBs in leaking capacitors enter the environment, the effect of the regulation would be to reduce the loss of PCBs from equipment by (1,340,000 pounds PCBs x 4% fail x 10% leak =) 5,360 pounds of PCBs. The rest of the PCBs in capacitors installed in equipment will end up in municipal landfills whether they are removed in 1979 or when the equipment fails.

All of the spare capacitors will have to be disposed of in chemical waste landfills, thereby preventing the entry into the environment of (124,000 pounds x 4% fail x 10% leak =) 496 pounds PCBs that would have occurred had these capacitors been used.

*Letter from George Hakin (Emerson Quiet Kool Co.) to EPA dated September 6, 1978.

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Municipal landfills are not as safe a repository for PCBs as are approved chemical waste landfills. However, PCBs are rather immobile in material with high organic content and would not be expected to leach out of municipal waste if present in low concentrations. No information is available on which any estimate can be made as to the fraction of the PCBs from intact capacitors that are expected to leach from municipal landfills.

3.5 Summary - Economic Impacts

Inventory losses: Spare capacitors $1 million

This cost will be reduced significantly or eliminatead if EPA grants exemptions from the "distribution in commerce" ban.

Inspection and rework: PCB Equipment $1 billion

This cost will be reduced significantly or eliminated if EPA grants exemptions from the 'distribution in commerce" ban.

Petition costs: $10 million*

3.6 Cost Per Pound of PCBs Kept From the Environment

Spare capacitors: $\frac{\$1 \text{ million}}{500 \text{ pounds}}$ = $2,000 per pound PCB

This cost will be reduced significantly or eliminated if EPA grants exemptions from the "distribution in commerce" ban.

Capacitors in equipment: $\frac{\$1 \text{ billion}}{5360 \text{ pounds}}$ = $187,000 per pound PCB

This cost will be reduced significantly or eliminated if EPA grants exemptions from the "distribution in commerce" ban.

*May be significantly reduced if EPA accepts class action petitions for exemptions to the ban on "distribution in commerce."

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4.0 IMPACTS ON USERS OF ASKAREL TRANSFORMERS

4.1 Present Status

In calculating the economic impact of the PCB Disposal and Marking Regulations, Versar estimated that there are about 140,000 transformers presently in service that were manufactured as PCB (askarel) transformers (Versar, 1977). These transformers were originally filled with a coolant liquid that contained from 60% to 100% PCBs. Although over 100 of these transformers have been retrofilled with silicone or hydrocarbon coolant liquids, none of them have been sufficiently decontaminated so that the concentration of residual PCBs is below 500 ppm.*

Approximately 1000 of the askarel transformers are installed on railway locomotives and commuter cars (Versar 1978, p. 19). These units are addressed specifically by the PCB ban regulations, and the impact of the regulations on these units is discussed in Chapter 5. Of the remaining units, most are pad mounted distribution and power transformers located in buildings and in electric generating stations, with a substantial number of askarel precipitator transformers being mounted on stacks. It is estimated that askarel transformers each contain an average of 2,500 pounds of PCB. The distribution of ownership of these askarel transformers was previously estimated to be as described in Table 4.1-1. No additional information on the ownership of askarel transformers was presented in the written or oral comments submitted to EPA after the PCB Ban Regulations were proposed.

*Enclosure with letter from Terry Michaud (Dow Corning Corp.) to EPA dated August 1, 1978.

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Table 4.1-1*

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

*Source: Versar, 1978, p. 19.

The PCB Ban Regulations define askarel transformers as being any transformers that are filled with a liquid containing PCBs in concentrations exceeding 500 ppm. This chapter discusses the impact of the regulation on transformers that were originally filled with a PCB based dielectric fluid. Chapter 6 discusses the impact of the regulation on those transformers that were originally filled with mineral oil but which have since become contaminated with PCBs in concentrations above 500 ppm.

4.2 Requirements of the Regulation

Rebuilding and major maintenance: The regulations forbid the removal of the core and coils from the transformer. As a result, any significant electrical problem involving the windings of an askarel transformer will result in the unit being scrapped. However, retrofilling a PCB transformer several times with a non-PCB liquid may reduce the residual concentration of PCBs to below 500 ppm. The ban on rebuilding does not apply to such decontaminated transformers.

Minor maintenance: There are no restrictions on the performance of maintenance that do not require removal of the coils. After July 1, 1979, transformer service companies cannot sell used or reclaimed askarel unless they have petitioned for an exemption from the provisions of the regulation which ban the processing of PCBs prior to their distribution in commerce.

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Reclaiming PCB askarel: After June 30, 1979, PCBs may be reclaimed for reuse only by those who have petitioned the EPA and been granted an exemption from the "processing" bans.

Storage of PCB askarel: Storage prior to use or resale must be in a specially marked area which meets the requirements established by the disposal regulations.

Disposal of failed transformers and PCB based askarel: No change from the previously promulgated Disposal and Marking Regulations.

Retrofill with non-PCB fluid: Authorized without restriction. The retrofilled transformer must continue to be considered a PCB transformer, until the liquid has been tested at least three months after the transformer was returned to service and found to contain less than 500 ppm PCBs. The transformer is then classified as a PCB contaminated transformer.

4.3 Economic Impact of the Regulation

Foregone savings from rebuilding

Askarel transformers have a normal service life of 30 to 40 years or more (Versar 1978, p. 7). Premature failure can occur as the result of electrical breakdown of the insulation or distortion of the coils caused by severe overload conditions. Normal industrial practice has been to rebuild failed askarel transformers by removing the core and coils, burning off the coils, and rewinding the coils using new wire on the original core. This repair normally costs about 60% of the price of a new transformer, and the repairs take about 25% as long as normal delivery of a new unit.* This rebuilding service is offered by both the original manufacturers of the transformers and by approximately 300 small transformer service companies.**

Based on an average price of $20,000 per new transformer (Versar 1978, p. 20), the ban on rebuilding askarel transformers will result in foregone savings of ($20,000 x (1-60%) =) $8,000 per transformer. In addition, the ban will increase the time required to restore service from

*Oral comments of Mr. Lynwood Holley (American Electric Apparatus Repair Corporation) at the hearings on the PCB Ban Regulations, August 28, 1978.
**Oral comments of Robert Sandman (Sandman Electric Company) at the hearings on the PCB Ban Regulations, August 28, 1978.

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the present one to two months to six months or more, depending on the availabilty of a satisfactory new transformer*. The out-of-service time might even be longer than would be expected based on past practices because the ban on the manufacture of new askarel transformers will require that each installation of existing askarel transformers be redesigned when the transformer fails and must be replaced. Adequate replacement transformers are usually available in a number of designs including oil-filled transformers with protective vaults and sprinklers, high fire point liquid-filled transformers, and various types of dry transformers. However, none of these designs are direct replacements for existing askarel transformers, so a certain amount of engineering time must be added to the normal delivery time for a new unit.

An active market in used askarel transformers existed in the past, but that market has declined over the past year due to uncertainties about the restrictions that EPA was expected to impose on the use of these units. The PCB ban regulations do not affect the resale and reuse of askarel transformers by users, and units removed from service because of changes in service demands might be made available as replacement units for some of the failed askarel transformers. However, the risk of a spill occuring during transport of an askarel transformer and the high potential liability incurred by any spill of PCBs will probably limit any market in used askarel transformers.

Not enough information is available to estimate the proportion of askarel transformers that would have been scrapped due to obsolescence rather than due to electrical failure; most existing askarel transformers have not been in service long enough for either aging or changing service demands to be significant. Assuming as an example that from one third to two thirds of the existing askarel transformers would have been rebuilt if it were not for the ban on rebuilding, the total foregone savings would be $8,000 per unit x 1/3 to 2/3 of the 140,000 units in service (Versar, 1978, pg. 21), or a total of $373 million to $747 million over the next 40 years.

*Letter from Robert L. Sandman (Electrical Apparatus Service Association, Inc.) to EPA (PCB Ban Regulation Hearing Record), Undated.

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These foregone savings will not be distributed evenly over the next 40 years because present failure rates of askarel transformers are relatively low. The failure rate is likely to increase as the average age of the transformers increases. It was previously estimated that approximately 80,000 gallons of PCBs were used in the repair of askarel transformers in 1974 (Versar, 1976a). This is enough PCB to fill 335 transformers with an average capacity of 240 gallons of liquid (Versar 1978, p. 21). Many transformer service companies have also used reclaimed askarel in rebuilt transformers, so the actual number of transformers rebuilt may be three to four times the number calculated from data on the use of new askarel (approximately 1200 per year). The amount of business lost to the transformer rebuilding industry due to the ban on the rebuilding of askarel transformers might be as much as (1200 transformers per year x $12,000 per unit =) $14.4 million per year. The transformer manufacturers would supply new units to replace those not rebuilt at an average cost of $20,000, so increased costs due to the regulation may be about (1200 units x $8,000 =) $9.6 million per year. Increased labor requirements by the manufacturers are expected to offset any job losses by the repair shops, and in fact little unemployment is expected in the transformer service industry because nearly all of the 300 companies that service askarel transformers also service oil-filled transformers. Since about 97% of large, pad mounted, liquid-filled transformers contain mineral oil, the ban on the rebuilding of askarel transformers should have a relatively small impact on the level of transformer repair business.

Lost service time

The delay in replacing failed askarel transformers might increase in some cases from the present four weeks required to rebuild a unit to as much as six months (Versar 1978, p. 21). This delay could have serious economic impacts on any industrial plant that was dependent on a single transformer for its power. Rental units might be available, but at a higher cost to the plant. The previous estimate of increased rental

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costs for temporary replacement transformers was $2,380,000 per year starting in 1979 (Versar, 1978). No additional data were submitted to the EPA in written or oral comments on the proposed regulation that would support any revision of this estimate.

Limitations on sale of reclaimed askarel

The regulations do not impose any restrictions on the processing of PCB based askarel by the owner of a transformer or by a service company that returns the askarel to transformers having the same owner. Therefore, there will be no restrictions on the present maintenance practice of periodically filtering the askarel in operating transformers to reduce the moisture content and improve its electrical properties. However, after June 30, 1979, sale of PCBs will be allowed only if the owner has petitioned the EPA for and been granted an exemption from the ban on the distribution in commerce of PCBs. If the EPA does not grant exemptions, there will be a lack of available PCBs to top off askarel transformers that may develop small leaks and to replace the PCBs absorbed by the filtering material when askarel is routinely filtered. However, since it is technically feasible to dilute askarel with various solvents, including trichlorobenzene, RTEmp®, and Iralec®, without damaging its electrical properties, there may be little economic impact caused by the ban on sale of new and reclaimed PCBs. It should be noted that PCBs from PCB tranformers that have been disposed of or are designated for disposal must be incinerated and therefore are not available for recycle or reuse.

Disposal of failed transformers and askarel liquids

The PCB Ban Regulations do not change the requirements previously imposed by the PCB Disposal and Marking Regulations in this area (EPA, 1978a), and therefore there are no additional economic impacts.

Retrofill with non-PCB fluid

The PCB Ban Regulations clarify the conditions under which a retrofilled transformer may be considered to be in the same class as oil-

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filled transformers for purposes of servicing and disposal. However, the regulations do not establish any limitations on retrofilling. Therefore, the effect of the regulations may be to reduce servicing problems when make-up askarel is no longer available and to reduce eventual disposal costs in some cases.

Ban on sale of PCBs

Effective July 1, 1979, neither unused PCBs nor reclaimed PCB based askarel will be allowed to be sold unless the seller has petitioned for and been granted an exemption by the EPA from the "distribution in commerce" ban. If the EPA does not grant exemptions, there will be a lack of available PCBs to replace askarels lost through small leaks or to replace the PCBs absorbed by the filtering material when askarel is routinely filtered. However, since it is technically feasible to dilute askarel with various solvents, including trichlorobenzene, RTEmp®, and Iralec®, without damaging its electrical properties*, there may be little economic impact caused by the ban on the sale of new and reclaimed PCBs.

Ban on processing PCBs for sale

The Toxic Substances Control Act defines the processing of a chemical as "the preparation of a chemical substance or mixture, after its manufacture, for distribution in commerce..." (Section 3(10)). Therefore, activities with PCBs that do not involve its sale are not considered to be "processing" as defined by the Act, and such activities performed for the purposes of maintaining transformers in other than a "totally enclosed manner" are specifically authorized by the regulation until July 1, 1984. This means that there are no restrictions on the filtering or other handling of askarel unless there is a change in the ownership of PCBs. Transformer askarel can continue to be tested and maintained by either the owner of the transformer or by a service company, but no PCBs can be added to the transformer except those that were owned by the owner of the

*Olmsted, J. (1977) "Comments and Recommendations on Makeup Fluid for Askarel Transformers", Waukesha, WI.: RTE Corporation, November 15, 1977. (Submitted to the PCB Regulation Hearing Record as an attachment to RTE Corporation "Main Comments").

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transformer no later than 30 days after the effective date of the regulation. In addition, "processing" and "distribution in commerce" for purposes of disposal are specifically authorized by the regulation.

The only significant impact of this provision will be to ban the salvaging of used PCBs by transformer service companies for use in maintenance of other transformers. However, the major use of such reclaimed askarels has been in rebuilt transformers, and the rebuilding of askarel transformers is being specifically banned. The economic impacts of the ban on "processing" PCB based askarels have been included in the estimated cost of the ban on rebuilding askarel transformers.

Disposal of failed transformers and askarel liquids

The PCB Ban Regulations do not change the requirements previously imposed by the PCB Disposal and Marking Regulations in this area (EPA, 1978a), and therefore there are no additional economic impacts.

Retrofill with non-PCB fluid

The PCB Ban Regulations clarify the conditions under which a retrofilled transformer may be considered to be in the same class as oil-filled transformers for purposes of servicing and disposal. The regulations do not establish any limitations on retrofilling. The effect of retrofilling may be to reduce servicing problems when make-up askarel is no longer available and to reduce eventual disposal costs in some cases. The ban regulations impose no economic costs relative to retrofilling of askarel transformers.

4.4 PCBs Controlled by the Regulation

The ban on rebuilding askarel transformers will eliminate the loss of PCBs to the atmosphere that occurs when a transformer is baked-out prior to removal of the coils. There is no information available on the PCB losses that occur during this process. However, if total losses of PCBs during rebuilding of an askarel transformer were controlled to one to ten pounds per unit, the regulation would reduce the entry of PCBs into the environment by (1 to 10 lbs per unit x 1/3 to 2/3 of 139,000 units =) 47,000 to 925,000 lbs.

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The ban on the sale of PCBs should accelerate the retirement of askarel transformers, but there is not sufficient information available to estimate the effect this will have on the amount of PCBs entering the environment.

4.5 Summary - Economic Impacts

Foregone savings from rebuilding:	$9.6 million (1979); $373 million to $747 million total
Lost service time (increased rental of replacement transformers):	$2.38 million per year

4.6 Cost Per Pound of PCBs Kept from the Environment

Ban on rebuilding

$$\frac{\$373 \text{ million to } \$747 \text{ million} + 23.8 \text{ million}^*}{47{,}000 \text{ to } 925{,}000 \text{ lb}} = \$429 \text{ to } \$16{,}400 \text{ per pound PCB.}$$

*Present value of one dollar per year indefinitely discounted at 10% equals $10.

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5.0 RAILROAD LOCOMOTIVE TRANSFORMERS

5.1 Present Ownership and Use Plans

Many of the major railroads in the northeastern United States are electrified. High voltage alternating current is supplied at 25 hz, 11,000 volts, by overhead catenaries to electric locomotives and multiple unit electric commuter cars (MUEC). Transformers on board the locomotives and MUEC cars reduce the voltage to the level required by the traction motors. These transformers are specially designed to fit into the limited space available on the car or locomotive and are built to withstand severe shock and vibration. The transformers incorporate a pump to force the coolant liquid through cooling fins and thereby improve the thermal efficiency of the units. It has been standard practice to use PCB based askarel coolant liquids in these transformers because of the possibility of a severe fire should a derailment occur in one of the tunnels leading into New York City.

The federally funded Northeast Corridor Improvement Project is upgrading much of the power distribution system between Washington, D.C. and New York City. According to Mr. Clifford Gannett of the Federal Railroad Administration, the scheduled completion date for conversion of the power on this portion of the railroad system is now September, 1983*. The conversion of the catenary power to 60 hz, 25,000 volts, will have a major effect on the continued use of many of the present askarel transformers on locomotives and MUEC cars operating in this area. Although some of the newer equipment can be converted to operate at the higher voltages by changing internal taps in the transformers, many of the

*Original information indicated 3rd quarter of 1982. Letter from Clifford Gannett (Federal Railroad Administration) to EPA dated September 18, 1978. Subsequent press reports indicated completion in September of 1983. This was confirmed by a telephone call to Mr. Gannett in February 1979 (See telephone memo dated February, 1979 from Harold Snyder, OTS/EPA to record.)

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transformers will have to be replaced, and the railroads intend to scrap many of the oldest cars and locomotives rather than to invest in the new transformers that would be required to keep them operating. Table 5.1-1 lists the ownership of the MUEC cars and locomotives using PCB cooled transformers that are presently in service and summarizes the effect of the voltage conversion on the continued use of these transformers.

5.2 Requirements of the PCB Ban Regulations

Use of PCB railroad transformers: Authorized until July 1, 1984 subject to the following limits on the concentration of PCBs in the dielectric liquid:

After January 1, 1982: 6% PCBs maximum
After January 1, 1984: 0.1% PCBs maximum

Servicing and retrofilling of PCB railroad transformers and treatment of PCBs in other than a totally enclosed manner: Authorized until July 1, 1984, provided that there is no change in the ownership of any PCBs.

Processing of PCB contaminated liquid prior to sale for servicing transformers: Banned after July 1, 1979, unless EPA grants an exemption from the "processing" ban regulation.

Sale of PCBs for servicing railroad transformers: Banned after July 1, 1979, unless EPA grants an exemption from the "distribution in commerce" ban regulation.

Testing of liquid in PCB railroad transformers to determine concentration of PCBs: Required immediately after any servicing that is performed to reduce the concentration of PCBs and again 12 to 24 months later. Records of these analyses must be maintained until January 1, 1991.

Rebuilding PCB railroad transformers in other than a totally enclosed manner: authorized until July 1, 1984. However, any transformer rebuilt after January 1, 1982, must be refilled with liquid containing less than 50 ppm PCBs.

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Table 5.1-1

Summary of PCB Cooled Railroad Transformers in Service (One Transformer per Car)

Owner	Type of Equipment	Number of PCB Transformers	Effect of Late 1982 Voltage Change: Number Cars Scrapped	Number Transformers Replaced	Number PCB Transformers to Remain in Service	Gal/Trans.
SEPTA	MUEC	344	38	74	232	
NJDOT	MUEC	122	18	0	104	
Conn DOT/MTA	MUEC	244	0	0	244	
MD DOT	MUEC	7	7	0	0	
Conrail	GG 1 Loco.	51	51	0	0	710
Conrail	E33, E44 Loco.	76	0	76	0	500
Amtrak	Metroliner	61	0	2	59	255
Amtrak	GG 1 Loco.	33	33	0	0	710
Amtrak	E60 Loco.	26	0	0	26	380
		964	147	152	665	

All data from letter to EPA from Mr. Clifford Garnett, Federal Railroad Administration, 9/15/78.

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Maximum concentration of PCBs in liquid used to service or top off railroad transformers:

No restriction until January 1, 1982. 6% PCBs from January 1, 1982, until January 1, 1984. 0.1% PCBs after January 1, 1984.

5.3 Cost Impacts of the PCB Ban Regulations

July 1, 1984 deadline on continued use of PCB railroad transformers:

It has not been demonstrated that it is technically possible to reduce the concentration of PCBs in PCB railroad transformers to below the 500 ppm level that is used to distinguish "PCB transformers" from "PCB contaminated transformers." It is anticipated that EPA will review the technology of retrofilling and processing of transformer liquids before the July 1, 1984, ban on the use of railroad transformers containing more than 500 ppm PCBs to assure that this requirement does not cause substantial economic impacts. Compliance with these regulations will therefore require that the affected railroads maintain close communication with EPA to resolve any unanticipated problems. There is not sufficient information in the record to support any estimate of the costs that will be incurred by the railroads in participating in the eventual review of these regulations.

Required reduction of PCB levels to below 6% by January 1, 1982:

It has been demonstrated that a single retrofilling procedure consisting of draining, flushing, and refilling with non-PCB coolant liquid can result in PCB concentrations substantially below 6% (Walsh, 1977;* Foss, 1977**). The analysis of the impacts of the proposed PCB regulation assumed a total materials and labor cost of $20 per gallon for retrofilling

*Walsh, E.J., D.E. Voytik and H.A. Pearce, (Westinghouse Electric Corp.) 1977. Evaluation of Silicone Fluid for Replacement of PCB Coolants in Railway Industry, Final Report. Report No. DOT-TSC-1294. Cambridge, Ma.: Transportation Systems Center, U.S. DOT. December 1977 (attachment to reply comments from Clifford Gannett (Federal Railroad Administration)).

**Foss, Stephen D., John B. Higgins, Donald L. Johnston, and James M. McQuade (General Electric Co.). 1977. Retrofilling of Railroad Transformers. Cambridge, Ma.: Transportation Systems Center, U.S. DOT, July 1978 (attachment to reply comments from Clifford Gannett (Federal Railroad Administration)).

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a transformer a single time with silicone liquid (Versar, 1978). A revised estimate for the cost of retrofilling a transformer based on the procedure developed by Dow Corning Corporation (Page, 1977)* is summarized in Table 5.3-1. The use of silicone at $12 per gallon (Versar, 1978, p. 30) in estimating retrofill costs should give an upperbound but reasonable figure because, although the alternative liquids may be cheaper, only silicone can be treated to remove dissolved PCBs by filtration.

The total cost of retrofilling the 964 existing PCB railroad transformers is calculated in Table 5.3-2 to be $6.6 million. Many of these transformers will be scrapped in late 1982 when the scheduled voltage change on the Northeast Corridor is made. It is therefore possible that at least some of the transformers will be replaced prior to January 1, 1982, with units which can operate at both the present voltage and the higher voltage that is planned. If this replacement is made prior to the date specified for the 6% PCB limit, the present transformers will not have to be retrofilled. The cost of this retrofill requirement can be calculated by assuming that all of the transformer replacements are made by January 1, 1982, and that retrofilling is only performed on the 665 transformers that will remain in service under higher voltage conditions. The cost of this limited retrofill program is calculated to be $3.7 million. If the changeover does not occur until September, 1983, all of the cars will have to be converted to non-PCB transformers in order to take advantage of the remaining useful life of the exisitng equipment.

*Page, William C. and Terry Michaud (Dow Corning Corporation). 1977. "Development of Methods to Retrofill Transformers with Silicone Transformer Liquid," IEEE Paper 22-477 presented at the Electrical Insulation Conference, Chicago, Illinois, September, 1977 (attachment to letter from Terry Michaud to EPA dated August 1, 1978).

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Table 5.3-1

Retrofill of PCB Railroad Transformer with Silicone - 300 Gallon Capacity Assumed

Step	Procedure	Cost: Materials	Estimated Labor-man hours
1	Hot drain askarel from transformer (85% removal - Foss, 1977)	5 drums @ $25.00* = $125.00	2 hours
2	Fill with 255 gallons trichlorobenzene, circulate and drain	255 gal TCB @ $5.21 = $1329.00	4 hours
3	Fill with silicone	300 gal silicone @ $12.00 = $3600.00	2 hours
4	Dispose of liquid (Rollins, 1978)***	10 drums @ ($115/drum disposal + $27.28 transportation @ $0.04/lb = $1423.00	---
	Sub-total:	$6477.00	8 hours @ $15.00**
	+ Labor Cost: @ $15. per hour	$120.00	
Total cost per transformer:		$6477.00	
	Cost per gallon:	$21.99	

*Versar 1977, pp. 3-8.
**Versar 1978, p. 33.
***Rollins Environmental Service, Inc. 1978. Indemnified Disposal Service for Polychlorinated Biphenyls (PCBs - Askarels), May 1, 1978. Submitted as an attachment to letter from James Thompson (T&R Electric Supply Co.) to EPA, dated August 28, 1978.

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Table 5.3-2

Cost of Retrofilling Railroad Transformers to Meet
January 1, 1982 Limit of 6% PCBs: $21.99/gal.

		Assume All Transformers Retrofilled			Assume Transformer Replacement Program Finished by January 1, 1982	
Owner	Equipment	Gallons/ Transformer*	Number of Transformers	Cost	Number of Transformers	Cost
SEPTA	MUEC	250	344	$1,891,000	232	$1,275,000
NJDOT	MUEC	250	122	671,000	104	572,000
CONN DOT/MTA	MUEC	250	244	1,341,000	244	1,341,000
MD DOT	MUEC	250	7	38,000	0	0
CONRAIL	GEL Loco	710	51	796,000	0	0
CONRAIL	E33, E84 Loco	500	76	836,000	0	0
AMTRAK	Metroliner	255	61	342,000	59	331,000
AMTRAK	GEL Loco	710	33	515,000	0	0
AMTRAK	E60 Loco	380	26	217,000	26	217,000
			Total:	$6,647,000		$3,736,000
				(302,000 gallons)		(170,000 gallons)

*Vaccar, 1978, p. 28.

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Required reduction of PCB levels to below 0.1% by January 1, 1984.

Reduction of the concentration of PCBs in each of 665 retrofilled transformers from an assumed average concentration of 5% to 1,000 ppm will require two separate retrofilling procedures, assuming that each retrofill reduces the amount of PCBs in the transformer by at least 86%. It was suggested that silicone liquid could be processed essentially in place to reduce the concentration of PCBs and that this processing would cost $4,600 per transformer + $25 per gallon of liquid in the transformer, or an average of $40.33 per gallon for a 300 gallon capacity transformer.* This estimate was based on an assumed loss of ten pounds of silicone per gallon of liquid treated by activated carbon, or a recovery efficiency of ~25% (i.e., 10 pounds of new silicone would be lost in processing and recovering 8 pounds of contaminated silicone). This analysis indicates that it would be cheaper to use new silicone at $12 per gallon, even though activated carbon has been shown to remove PCBs from silicone.** The cost of each retrofill would be $15.14 per gallon as calculated in Table 5.3-3. Total cost to the railroads for the two retrofill procedures required to reduce the PCB concentration in each transformer to below 1000 ppm would then be (170,000 gallons x 2 retrofills x $15.14 per gallon =) about $5.15 million. This cost could be reduced if a less expensive disposal method became available or if some way were developed to reclaim the silicone.

*Attachment 2 to "Comments on Proposed Regulations to Ban PCBs." Submitted by General Electric Co. as a written comment to the EPA Hearing Record on the PCB Ban Regulations. Undated.

**Dow Corning Corporation. Removal of PCB from Dow Corning 561® Transformer Liquid by Charcoal Filtration, Midland, Michigan: Undated (As cited in Versar, 1978, p. 29).

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Table 5.3-3

Retrofill of Contaminated Silicone Filled Transformer - 300 Gallon Capacity Assumed

Step	Procedure	Cost: Materials	Labor-man hours
1	Hot drain silicone (85% removal of liquid)		2 hours
2	Flush with 45 gallons silicone, (additional 3% removal of PCBs)	$540.	2 hours
3	Refill with 255 gal. new silicone ($12/gallon)	$3060.	2 hours
4	Disposal of 6 drums contaminated silicone (@$142)	$ 852.	
	Sub-total:	$4452.	6 hours
	Plus Labor Cost @ $15/hour:	$90.	
	Total cost per transformer:	$4542.	
	Average cost per gallon:	$15.14	

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It should be noted that the highest calculated total cost of the retrofill program of $21.82/gallon (Table 5.3-1) + 2 x $15.14/gallon (Table 5.3-3) = $52.10/gal is somewhat less than the estimated cost of $78 per gallon assumed by Charles Engelhardt of Amtrak and by Dean Aboudera of the American Public Transit Association in their oral comments at the August 31, 1978, hearings on the proposed PCB Ban Regulation. However, it is felt that the estimate of $52.10 per gallon is in fact an upper bound estimate of the cost impact of the PCB Ban Regulation because of the opportunities available for cost reduction by use of other materials being evaluated by the Federal Railroad Administration such as RTEmp® and Iralec T-1®.*

Testing to determine concentration of PCBs in liquid.

Testing of the liquid in each railroad transformer that remains in service will apparently be required four times: upon completion of each of the three retrofill procedures and again 12 to 24 months after the completion of the final retrofill. Only the initial testing will be required for those transformers that are replaced in late 1982. There has been no information submitted to the EPA on the recommended methodology or estimated cost of analyzing samples of silicone oil for the presence of PCBs. The methodology for this analysis should be about the same as for PCBs in mineral oil, although the silicones would require additional maintenance of the column in the gas chromatograph. Cost of each analysis therefore might be $125 to $150, including order processing costs. Total cost of the required analyses would be expected to be $440,000 as calculated in Table 5.3-4.

*Oral comments by Clifford Gannett (Federal Railroad Administration) at August 31, 1978 hearing.

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Table 5.3-4

Cost of Analyzing Silicone Oil for the Presence of PCBs in Retrofilled Railroad Transformers

Initial retrofill: 964 Samples @ $150	=	$144,600
3 x 665 transformers @ $150	=	$299,250
Total analytical cost	=	$443,850.

5.4 PCBs Controlled by the Regulation

There are presently about 4,000,000 pounds of PCBs in use in railroad transformers. The final disposal of this material was regulated by the PCB Marking and Disposal Regulations. The effect of the present regulations is to reduce the amount of PCBs lost by leakage of transformers by requiring that the PCBs be removed from the transformers and be replaced with other liquids. Although it was noted that railroad transformers often lose liquid by leaks and venting, no information was presented to the record that would support a quantitative estimate of the PCBs required to top off these transformers to replace lost liquid. Therefore, no estimate can be made of the effect of the required retrofill program on the entry of PCBs into the environment.

5.5 Summary - Economic Impacts

Cost of reducing PCBs to 6%	$6.6 million (silicone in 964 transformers).
Cost of reducing PCBs to 1000 ppm	$5.15 million (silicone in 665 transformers).
Analytical Costs:	$444,000

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5.6 Cost Per Pound of PCBs Kept from the Environment

At best, each retrofill prevents the entry into the environment of the amount of PCBs removed from the transformers.

Reduce PCBs to 6%:

$$\frac{\$6.6 \text{ million} + \$140{,}000}{.94 \times 4 \text{ million pounds}} = \$1.75^{*} \text{ per pound PCB}$$

Reduce PCBs to .1%:

$$\frac{\$5.15 \text{ million} + \$300{,}000}{170{,}000 \text{ gallons} \times 8 \text{ lb/gal} \times 5.9\% \text{ PCBs}} = \$68^{*} \text{ per pound PCB}$$

*Assumes all PCBs would be lost to the environment if not removed by retrofilling.

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6.0 OIL-FILLED POWER AND DISTRIBUTION TRANSFORMERS

6.1 Present Contamination of Oil Filled Transformers

The PCB ban regulations lower the level at which PCB contaminated mineral oil is regulated from 500 ppm to 50 ppm. A mineral oil transformer may fall into one of three categories. A mineral oil transformer that has been tested and found to contain over 500 ppm PCBs is classified as a "PCB Transformer." A transformer that has not been tested or that has been tested and found to contain between 50 ppm and 500 ppm PCBs is a "PCB-Contaminated Transformer." Transformers that have been tested and found to contain less than 50 ppm PCBs are not subject to regulation.

Most liquid-filled transformers have been filled with transformer oil, a non-chlorinated petroleum product similar to SAE 10 motor oil (Versar, 1976a, p. 255). These transformers are similar in design to PCB askarel transformers, and many of the oil-filled transformers were built in the same plants that manufactured askarel transformers (Versar, 1976a, p. 84). The total number of oil-filled transformers presently in service was previously estimated to be about 30,000,000 overhead and distribution transformers (each containing an average of 16 gallons of oil) and 5,000,000 other distribution and power transformers (each containing an average of 250 gallons of oil) (Versar, 1978, pp.36-39). It was also estimated that nearly all of the pole mounted transformers and perhaps 80% of the other oil-filled transformers are owned by electric utilities (Versar, 1978, pp. 39-40).

During the hearings on the proposed regulation, a number of utilities and transformer repair companies presented information on the results of sampling programs that they conducted to evaluate the extent of PCB contamination of oil-filled transformers. This information is summarized in Tables 6.1-1 and 6.1-2. The reply comment from the Edison

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Table 6.1-1

Utility Reports of PCB Contamination of Oil Filled Transformers with Concentrations Above 50 ppm

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
Allegheny Power Service Corp.	1	0 of 2	9 of 33* 0 of 2	oil storage tanks: 0 of 2	* 33 randomly selected substation transformers. Other 6 samples were not part of the random sample.
Boston Edison	2	—	—	1 oil storage tank: PCBs <5 ppm	
Commonwealth Edison	3	0 of 9	4 of 12		100 selected to be representative of age of operating transformers; no data on how these 21 samples were chosen to be analyzed first, (210 ppm max).
Consumers Power	4	—	4 of 29	55 gallon drums of oil: 0 of 4	Many samples were submitted from a repair shop. Others are samples taken from transformers in various parts of the state.

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Table 6.1-1 (Continued)

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
Dayton Power and Light	5	—	5 of 17 (in service) 0 of 9 (new)		Some of the 17 used transformers were selected because it was known that PCBs were used in the plants where they were manufactured.
Detroit Edison	6	—	2 of 4 *	Reclaimed oil storage tanks: 0 of 3	* maximum = 80 ppm.
Duke Power Co.	7	—	51 of 161 *		Only transformers rated at less than 44 kv; higher voltage units thought to be less contaminated. * of 161 sampled, 3 were above 500 ppm, 7 between 100 and 500 ppm, 41 present below 100 ppm but not quantified. "....it was assumed that all samples with detectable amounts of PCBs were contaminated above [illegible]

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Table 6.1-1 (Continued)

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
GPU Service Corporation	8	15 of 58 distribution transformers	—	oil storage tanks: 2 of 18	4 in range 100-499 ppm, 2 above 500 ppm.
GPU Service Corporation	9	—	25% of oil in 144 sub-station transformers		
Northern States Power Co.	10	(0 of 6)			Transformers at repair shop.
Ottertail Power Company	11	—	0 of 1	oil storage tank: 0 of 1 (31.4 ppm)	
TVA	12	—	2 of 38	—	Planned random sample.

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Table 6.1-1 Notes

1/ Letters from Nancy H. Gormley (Allegheny Power Service Corp.) to EPA dated August 4, 1978 and September 7, 1978.

2/ Letter from Charles Dolloff (Boston Edison Co.) to EPA dated July 5, 1978.

3/ Letter from John Hughes (Commonwealth Edison) to EPA dated August 4, 1978.

4/ Letter from Nathan Haskell (Consumers Power Co.) to EPA dated August 7, 1978.

5/ "Supplemental Comments" submitted to EPA by Harold F. Fox (Dayton Power and Light Company), August 18, 1978.

6/ Letter from Skiles Boyd (Detroit Edison) to EPA dated August 3, 1978.

7/ Written Comments - "Response Concerning EPA's Proposed PCB... Bans..." - submitted by Duke Power Co., August 4, 1978 and oral comments by Mr. N. J. Malton (Duke Power Co.) at the PCB Hearings, August 21, 1978.

8/ Letter from J.R. Thorpe (GPU Service Corp., a subsidiary of General Public Utilities) to EPA dated August 4, 1978.

9/ Letter from Edmund Newton, Jr. (GPU Service Corporation) to EPA dated October 6, 1978.

10/ Oral Comments of Lyle Salmela (Northern States Power Company/Mid-Continent Area Power Pool) at PCB Hearings, August 22, 1978, (pp. 78-79 of transcript).

11/ "Comments of Ottertail Power Co. on the Proposed Amendments to 40 CFR 761." Undated.

12/ Letter from William Gerstner and Paul Greiner (Edison Electric Institute) to EPA dated August 7, 1978; Exhibit III.

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Table 6.1-2

Transformer Manufacturer and Service Company Reports of PCB Contamination of Oil Filled Transformers Above 50ppm.

Company	Reference Note Number	Pole Mounted Distribution Transformers	Other Transformers	Other Samples	Sampling Procedure
General Electric	1	4 of 75	8 of 164		Samples analyzed at Customer request. Note: These two groups of data from GE may overlap.
General Electric	2	(25 of	55)		
RTE	3	(0 of	19)		
T&R Electric Supply	4	6 of 14		2 oil storage tanks: 72ppm and 82ppm	Random sample of used pole mounted transformer in inventory. Average 103ppm PCBs.
Transformer Consultants	5	(185 of	434)		On customer request - primarily industrial clients; 72 of the transformers had more than 500ppm PCBs, although several of these may have been retrofilled askarel transformers.

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Table 6.1-2 Notes

1. Letter from William Gerstner and Paul Greiner (Edison Electric Institute) to EPA dated August 7, 1978. Exhibit III.

2. Versar. 1978, p. 40. Confirmed in letter from James Young (General Electric) to EPA dated October 6, 1978.

3. "Main Comments..." submitted in writing to EPA by John Olmsted (RTE Corporation) undated.

4. Letter from James Thompson (T&R Electric Supply Company, Inc.) to EPA dated August 28, 1978.

5. "Response to June 7, 1978 Federal Register Regarding Proposed Change in PCB Regulations" submitted to EPA by Stanley Meyers (Transformer Consultants) as an attachment to letter dated September 13, 1978.

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Electric Institute (EEI) also summarized this information. The EEI summary is included as Tables 6.1-3 and 6.1-4. Since the EEI tables use a different definition of distribution transformers (including more than just the pole mounted units) and include the results of sampling of oil storage tanks in the totals, the resulting tables are not directly comparable to 6.1-1 and 6.1-2. However, the EEI apparently had access to some data on oil-filled transformers that was not otherwise presented to the EPA.

The only data on contamination of oil-filled transformers that were based on a reasonably random sample of transformers presently in service were the data reported by Allegheny Power, Commonwealth Edison, and TVA. The samples taken by Duke Power were from a population that excluded the large transformers which Duke Power believed were not contaminated. The other utilities sampled on the basis of convenience, usually sampling transformers that were in the shop for repairs or that were being serviced in the field. RTE Corporation reported data based on a planned random sample of transformers which they had built. Although RTE reportedly has never used PCBs in their manufacturing plant, they reported that the level of PCBs seen in transformers was higher in the older units than in newer ones (none of the transformers was found to be contaminated in concentrations above 50 ppm). T&R reported a random sample of used transformers and stated that they felt that the average concentration of PCBs in oil was above 50 ppm because their holding tanks for reclaimed oil contained more than 50 ppm PCBs. GE and Transformer Consultants reported the results of analyses done on their own samples and for other companies; these data may have also been reported by the owners of the transformers and may therefore be duplicate information.

It is not possible to calculate statistics that describe all transformers from the data that has been reported because of problems in sampling protocols, possible double reporting of data, and uncertainties

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Table 6.1-3

Edison Electric Institute Summary of Contaminated Transformer Data Submitted by Electric Utilities*

	Distribution[1]		Power		Total[2]		
	No.	> 50 ppm	No.	> 50 ppm	No.	> 50 ppm	> 500 ppm
Comm. Ed.	26	-	17	5	43	5	-
TVA			34	2	38	2	
Consumers					33	4	
Duke			161[3]	51	161	51	3[4]
Allegheny	2	-	20	2	39	9	
GPU			-	-	76[5]	17	2
Georgia			24	-	24	-	
Detroit			4	2	14	2	
Dayton	9	-	17	5	26	5	
Boston Ed					1	-	
Ottertail					1	-	
TOTAL	37	0	277	67	456	95	5
	0%		24%		21%		1%

* Source: Letter from William Gerstner and John Kearney (Edison Electric Institute) to EPA dated October 10, 1978. Appendix B. Appended notes also from Edison Electric Institute.

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Notes to Table 6.1-3

1/ See ANSI/IEEE C-57.80 (1978). This definition includes but is not limited to pole-type and residential pad-type transformers.

2/ Includes oil storage facilities and other PCB articles.

3/ As indicated by Duke Power Co. in its hearing testimony (August 21, 1978, at Tr. 113) its sampling program was not representative of its system. Rather, it was designed to sample those transformers "most likely to be PCB-contaminated." Id.

4/ As indicated in the Duke Power Co. Hearing Testimony (Aug. 21, 1978, Tr. at 134) the 3 samples indicating concentration greater than 500 ppm were from transformers manufactured by the same company at least one of which was incorrectly filled with askarel by the manufacturer. Id. at 129. We strongly believe that any contamination greater than 500 ppm is most unusual and unique and is not at all representative of the 35 million mineral oil transformers.

5/ Includes 58 transformers not identified as to power or distribution of which 15 (26%) contained mineral oil dielectric contaminated with PCBs at levels greater than 50 ppm.

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Table 6.1-4

Edison Electric Institute Summary of Contaminated Transformer Data Submitted by Transformer Companies * (1)

	Distribution[2]		Power		Total		
	No.	>50 ppm	No.	>50 ppm	No.	>50 ppm	>500 ppm
General Electric[3]	261[4]	20	13	6	294	37	
RTE	19	-			19	-	
T & R Electric[5]	14[6]	6			14	6	
Transformer Consultants[7]			434[8]	185	434[9]	205	65
TOTAL	294	26	447	191	761	248	65
	9%		43%		33%		15%

* Source: Letter from William Gerstner and John Kearney (Edison Electric Institute) to EPA dated October 10, 1978. Appendix C. Appended notes also from Edison Electric Institute.

MONS 0132666

Notes to Table 6.1-4

1/ Westinghouse has not provided any independent evidence in its comments of the contamination of mineral-oil transformers with PCBs. Its evaluations are solely based on assumptions it makes using the comments and testimony of others for the purpose of demonstrating the economic impact of the proposed regulations.

2/ See ANSI/IEEE C-57.12.80 (1978). This definition includes but is not limited to pole-type and residential pad-type transformers.

3/ GE admits that it has "no idea how to tackle the problem of what percentage of the oil is contaminated" and that "no statistical basis for any conclusion exists in General Electric." R.C. Osthoff, letter to Dr. E.L. Simons (July 3, 1978). In particular, the assertion on page 5 of its Main Comments that 3-10 million pole-type distribution transformers may contain in excess of 50 ppm PCBs is without foundation.

4/ Includes 75 pole-type transformers of which 4 (5%) were above 50 ppm.

5/ T&R Electric buys and sells used transformers. Its sample survey is not statistically "representative" of its inventory, the electric utility industry, or the class of 35 million mineral-oil transformers.

6/ Pole-type transformers. See August 28, 1978 Tr. at 126.

7/ Transformer Consultants is a transformer servicing company. Transformer Consultants has orally informed us that it has now analyzed roughly 2,000 oil samples of which approximately 33% contained greater than 50 ppm PCBs and 10% contained greater than 500 ppm PCBs. Inasmuch as roughly two-thirds of its customers are industrial and the remainder are small utilities, none of the samples conducted by Transformer Consultants is representative of the electric utility industry.

8/ Generally transformers of 200 kva or greater.

9/ See, Reply Comments of Transformer Consultants (September 13, 1978). Note: These numbers differ from those submitted by Mr. Westin on September 26, 1978.

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about the analytical methodology that was used in each case. However, from inspection of the data, it might be reasonable to conclude that from 5% to 40% of pole mounted transformers and from 20% to 30% of other oil-filled transformers are contaminated with PCBs in concentrations exceeding 50 ppm. Contamination to levels above 500 ppm appears to be rare. Table 6.1-5 summarizes calculations of the amount of PCBs in all transformers and the amount present in transformers contaminated above 50 ppm. Because of the uncertainties in the data, the range of confidence in these estimates must be at least a factor of four, i.e., each estimate should be bounded by a range of -80% to +400%.

Approximately 80% of the oil-filled transformers are owned by electric utilities, including the 149 class A and B operating companies and approximately 1000 Rural Electric Cooperatives.* About eight million of the pole mounted transformers are owned by the 1000 rural systems, of which 950 are distribution cooperatives that do not generate any power* and that therefore do not have high efficiency boilers.

6.2 Requirements of the PCB Ban Regulation

The regulation defines a class of PCB equipment called "PCB Contaminated Transformers" and specifies certain exemptions from the marking, disposal, and ban requirements that apply to other PCB equipment. "PCB Contaminated Transformers" include (1) transformers which were not originally filled with a PCB coolant liquid but that now are known to contain a liquid contaminated with PCBs in concentrations from 50 ppm to 500 ppm, (2) oil-filled tranformers that have not been tested for PCBs, and (3) transformers that were originally filled with PCB based askarel but that have been decontaminated to the extent that the concentration of PCBs is found to be below 500 ppm when tested after at least three months of service following the last decontamination procedure.

*Ives, Joseph S. (National Rural Electric Cooperative Association). Written statement dated August 7, 1978, and oral testimony at August 21, 1978 hearing.

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Table 6.1-5

Estimated Amounts of PCBs in Oil-Filled Transformers

	Pole Mounted	Other
Average oil capacity, gallons per transformer*	16 gal.	250 gal.
x 7.6 = lb oil per transformer	121.6 lb	1900 lb
Number of transformers in service*	30,000,000	5,000,000
% above 50 ppm	10%	25%
Number of transformers above 50 ppm	3,000,000	1,250,000
Pounds of oil in contaminated transformers	364.8 million lb	2,375 million lb
Assumed average PCBs concentration	80 ppm	80 ppm
Pounds of PCBs in contaminated transformers	29,184 lb**	190,000 lb**
Number of transformers below 50 ppm	27,000,000	3,750,000
Pounds of oil in non-contaminated transformers	3,283 million lb	7,125 million lb
Assumed average PCB concentration	10 ppm	20 ppm
Pounds of PCBs in non-contaminated transformers	32,830 lb**	142,500 lb**
Total pounds of PCBs	62,000 lb**	332,500 lb**

Total 400,000 lb PCBs**

*Versar, 1978, pp. 36-40

**Confidence limits: - 80% + 400%

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The following provisions apply to "PCB Contaminated Transformers":

- Continued use: defined as use in a totally enclosed manner, and therefore not regulated.

- Marking: exempted from the requirement that a PCB label be applied.

- Servicing and rebuilding in other than a totally enclosed manner: authorized until July 1, 1984, provided there is no change of ownership of liquid containing over 50 ppm PCBs. (Note: reclaimed transformer oil may be presumed to contain between 50 and 500 ppm PCBs unless it has been tested.)

- Reclaiming used transformer oil: authorized without restriction for use by the owner of the oil in his own transformers.

- Sale of reclaimed transformer oil: tested and found to contain less than 50 ppm PCB: not regulated.

  Not tested for PCBs or tested and found to contain 50 to 500 ppm PCB: banned after June 30, 1979, unless EPA grants an exemption from the "distribution in commerce" bans. EPA has not yet announced the conditions under which individual and consolidated petitions for exemption will be accepted.

- Resale of used transformers: excluded by TSCA from the "distribution in commerce" ban.

- Disposal of drained transformers: not restricted.

- Disposal of used transformer oil: tested and found to contain no detectable PCBs: not regulated. (Testing may be performed on batches of oil from different transformers, i.e., testing of storage tanks is permitted.)

  Tested and found to contain detectable PCBs in concentrations below 50 ppm - not regulated, except the oil may not be used

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as a sealant, coating, or dust control agent (i.e., not allowed as road oil or pesticide carrier).

Not tested or tested and found to contain 50 to 500 ppm PCBs: storage and shipping containers must have PCB label. Storage must be in special PCB storage areas and shipping vehicles must be marked. Disposal must be in one of the following:

(1) In an approved PCB incinerator.

(2) In an approved chemical waste landfill.

(3) In a large (50 million BTU per hour or larger) high efficiency boiler that meets certain specified operating criteria. The EPA Regional Administrator must be notified 30 days before the first time PCB contaminated oil is burned.

(4) By any other method that has been demonstrated to have as high a destruction efficiency for PCBs as does a high efficiency boiler and that has been approved for disposal of PCB-contaminated oil by the EPA Regional Administrator.

6.3 Cost Impacts of the PCB Ban Regulation

The regulation does not affect the continued use or resale of PCB contaminated transformers, nor does it affect the maintenance of these transformers except to ban the sale of reclaimed contaminated fluid. The only impacts will be on the reclamation and disposal of contaminated used transformer oil and other contaminated transformer liquids.

July 1, 1984 deadline on rebuilding oil-filled transformers:

After July 1, 1984, rebuilding of oil-filled transformers will only be allowed for those units that have been tested and found to contain less than 50 ppm PCBs. It is anticipated that EPA will review the status of the rebuilding of transformers and the occurrence of PCBs in the oil of oil-filled transformers prior to the 1984 deadline. Those companies that rebuild transformers will therefore have to stay in close contact with EPA and participate in the regulatory review process in order to ensure that this deadline does not result in major unforeseen economic impacts. There is not sufficient information to support any estimate of the costs to be

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incurred by the transformer service industry and by the users of oil-filled transformers by participating in the eventual review of these regulations.

Reclamation of used fluid from PCB contaminated transformers:

According to Duke Power Company, reclaiming and reprocessing transformer oil saves at least $.40 per gallon on the 170,000 gallons of oil which they reprocess in-house each year.* The Cincinnati Gas and Electric Company reported that they salvage 60,000 gallons of used transformer oil each year from their transformer repair operations and that this is reprocessed into 58,000 gallons of useable oil at a total cost of $18,000 or $.31 per gallon.** New transformer oil presently costs about $1.19 per gallon** and the price is expected to increase over the next few years as supplies of naphthenic crude oil are depleted and transformer oil must be made by the more expensive process of deeply dewaxing paraffinic crude oil fractions.

Not all used transformer oil is reclaimed because smaller transformer companies and utilities do not generate enough used oil to justify the purchase of the necessary equipment. However, reclamation appears to be the standard practice for most transformer repair shops and major utilities. The regulations authorize the reclamation of used transformer oil by utilities for use in their own transformers. The regulation requires that all transformer oil be presumed to contain more than 50 ppm PCBs unless it has been tested and found to contain less than 50 ppm PCBs. The sale of reclaimed transformer oil is banned after June 30, 1979, unless each batch has been shown to have less than 50 ppm PCBs or EPA exempts the seller from this ban requirement. The EPA has not yet

*"Duke Power Company's Response..." dated August 4, 1978. Submitted to EPA as a written main comment on the proposed PCB ban regulation.
**Letter from E. E. Galloway (The Cincinnati Gas and Electric Company) to EPA dated August 4, 1978.

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established the basis on which it will accept individual or consolidated petitions for exemption, nor has it announced the basis for granting such exemptions. The filtering of oil by transformer service companies as a part of routine field maintenance is allowed because the oil is returned to the transformer from which it is taken and ownership of the oil does not change, so there is no "distribution in commerce" taking place.

As calculated in Table 6.3-1, approximately 78% of the transformer oil is in transformers owned by large utilities, most of which do their own routine maintenance.

Maintenance of most of the transformers not owned by the major utilities is performed by transformer manufacturers and by independent repair shops. About 8 million of the 30 million pole mounted distribution transformers are owned by small distribution utilities most of which do not repair their own transformers. As calculated in Table 6.3-1, the effect of the ban on the sale of reclaimed oil is to eliminate the opportunity to recycle 22% of the available oil unless each batch is tested and shown to contain less than 50 ppm PCBs. If it is assumed that 4% of all oil becomes available for recycling each year (equivalent to assuming an average of 25 years between major servicing operations on each transformer) and that 75% of the oil was actually recycled, savings in 1978 would have been (1.73 billion gallons x 4% available x 75% reclaimed x $.40 to $.80 per gallon savings per gallon reclaimed =) $20.8 million to $41.5 million. The cost of the foregone savings from recycling in 1979 could be as much as 22% of the 1978 savings, or $4.6 million to $9.2 million.

The actual reduction in the amount of oil reclaimed by transformer shops will depend on the economics involved in testing the oil to demonstrate that each batch contains less than 50 ppm PCBs. The total amount of oil that could be reclaimed for purposes of resale by transformer maintenance shops might be 11.4 million gallons per year as calculated in Table 6.3-2. If this oil were accumulated in 1000 gallon batches prior to

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Table 6.3-1

Used Transformer Oil Available for Reclamation

	Pole Mounted Transformers	Other
Average capacity-gallons	16	250
Total number in service	30,000,000	5,000,000
Owned by industry	-	900,000
Owned by small utilities	8,000,000	100,000
Owned by major utilities	22,000,000	4,000,000
Amount of oil in use	480 million gal	1,250 million gal
Total	1,730 million gal	
Amount of oil used by major utilities	352 million gal	1,000 million gal
Total	1,352 million gal	

Percent of transformer oil used by major utilities:

$$\frac{1,352 \text{ million gal.}}{1,730 \text{ million gal.}} = 78\%$$

Percent of transformer oil not available for recycling: 1-78% = 22%

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Table 6.3-2

Estimated Supply of Transformer Oil Available for Recycling for Sale

Total amount of oil	1.73 billion gallons
x fraction available each year	4%
x fraction to transformer repair companies	22%
x fraction assumed recoverable (not too degraded by prolonged use)	75%
= Total annual supply of oil available for recycling for sale	11.4 million gallons

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testing, all of the oil could be tested for PCBs by performing 11,400 analyses. Costs of such a routine sampling and analysis program were previously estimated to be from $67 to $80 per sample (Versar 1978, p. 41). The cost of performing such an analysis on a 1000-gallon tank full of oil would be only $.08 per gallon. Testing to prove that the oil could be reclaimed would be justified as long as the expected cost per gallon reclaimed is less than the cost savings of $.40 per gallon achievable by reclaiming the oil. Therefore, the analysis of 1000-gallon batches would be justified if as few as one of every five batches were actually found to have less than 50 ppm PCBs. If the total amount of PCBs in transformers is actually the 400,000 pounds estimated in Table 6.1-5, the average concentration of PCBs in the 1.73 billion gallons of transformer oil that is in use would be about 30 ppm. This implies that at least one half of the batches of oil that are tested would have less than 50 ppm PCBs if care were taken to avoid contamination of the oil with materials used with askarel transformers. If only one half of the batches were in fact contaminated to levels of less than 50 ppm, an expenditure of (11,400 analyses at $80 =) $912,000 for chemical analyses would make available (11.4 million gallons x 50% =) 5.7 million gallons of oil per year for recycling and resale. If the recycling of this oil saves $.40 to $.80 per gallon, the total cost of the ban on selling untested recycled transformer oil would be reduced by (5.7 million gallons x $.40 to $.80 per gallon - $912,000 testing cost =) $1.368 to $3.468 million per year. Total costs would then be ($4.6 to $9.2 million - $1.4 to $3.6 million =) $3.2 to $5.6 million per year. If, however, none of the batches of oil had over 50 ppm PCBs, the total cost of the regulation would be the cost of the analyses (or a total of $912,000 per year if testing were performed on batches of 1000 gallons) or even less if the average batch size were larger.

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Disposal: The PCB Ban Regulation authorizes the disposal of transformer oil contaminated with 50 to 500 ppm PCBs in large, high efficiency boilers meeting certain requirements of size, feed rate of the contaminated oil, presence of excess oxygen in the stack gas, specified instrumentation and monitoring procedures, and other specified operating conditions. The contaminated oil would have to be handled and labeled as PCBs during shipment and storage.

The regulations require that the EPA Regional Administrator be notified at least 30 days before the first time each high efficiency boiler is used to burn transformer oil known or presumed to be contaminated with PCBs. The regulations further state that the contaminated oil cannot be fed into the boiler during start-up or shut-down conditions and that the oil can comprise only ten percent of the fuel while the boiler is operating. Therefore, special holding tanks and metering pumps will be required to feed the transformer oil into the fuel stream in a controlled amount during periods of stable operation of the boiler.

A number of utilities have stated that they have power boilers that operate at combustion conditions similar to those specified for PCB incinerators.* A special holding tank and metering pumps will be required to feed contaminated transformer oil into a high efficiency boiler. Additional road construction, fencing, or other utilities may add to the cost of equipping a boiler to burn transformer oil in compliance with the regulation. This expenditure would probably only be made if justified by savings resulting from (1) decreased disposal costs and (2) the value of heat recovered in burning the transformer oil.

*Letter from Nancy Gormley (Allegheny Power Service Corporation) to EPA dated August 4, 1978.
*Letter from James Mulloy (City of Los Angeles Department of Water and Power) to EPA dated August 7, 1978.
*Attachment to letter from L. John Cooper (Nebraska Public Power District) to EPA dated August 4, 1978.
*"Comments of Otter Tail Power Company on the Proposed Amendments to 40 CFR 761." Submitted to EPA by Jay D. Myster, undated.
*Letter from S. A. Ali (Public Service Indiana) to EPA dated August 4, 1978.

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Disposal of used transformer oil in approved high temperature PCB incinerators has been quoted to cost $.08 per pound in tank truck lots (Rollins, 1978) plus perhaps $.02 per pound transportation (Versar, 1977, pp. 2-32). This is roughly $.75 per gallon. T&R Electric estimated that fuel oil to replace transformer oil used in their boiler would cost $.42 per gallon.* Shipping costs to move transformer oil in drums to boilers equipped to burn it will probably not exceed the commercial trucking costs of $2.70 per hundred pounds for trips under 100 miles (Versar 1977, p. 2-33). For transformer oil weighing 8 pounds per gallon, this is equivalent to ($2.70/8 =) $.34 per gallon. Shipment of large quantities by tank truck would be considerably cheaper per gallon. The value of the oil to the company that owns and burns it would be equal to the savings in disposal cost ($.75 per gallon) plus the net fuel value ($.42 -$.34 = $.08 per gallon). Even though most utilities might be able to obtain fuel for their power boilers at a lower cost than is paid by T&R Electric, the savings in disposal cost of $.75 per gallon could quickly pay for the estimated cost of installing additional handling facilities at the boiler.

Since the value of used transformer oil as fuel is roughly equal to the cost of handling and transporting it, the total cost of disposal to those utilities that have suitable boilers will be the cost of equipping the boilers. There is not sufficient information in the record to support an estimate of the cost of installing this equipment, but this alternative disposal method should be considerably cheaper than commercial approved PCB incineration for most of the 149 class A and B utilities.

*Letter from James Thompson (T&R Electric Supply Company, Inc.) to EPA dated August 28, 1978.

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Satisfactory high efficiency incinerators will not be generally available to the many distribution utilities, transformer repair shops, and industrial owners of oil-filled transformers. For instance, T&R Electric is a transformer repair shop that burns 200,000 gallons of used transformer oil each year in a hot water generator which has a flame temperature of 1700° F.* The regulations will require that this oil be disposed of by incineration in high efficiency boilers or by other approved methods. This will result in increased costs to T&R Electric both to dispose of this oil and to replace it.

If the requirement that waste oil be labeled as PCBs discourages general handling of this material, the value of the used oil to the company that generates it may be considerably less than its potential fuel value. The result may be disposal costs of up to $.75 per gallon. Since much of the waste oil is now used as supplemental fuel in small boilers that will not meet the requirements established by the regulation, the opportunity cost of the regulation may be up to ($.75 disposal cost + $.42 fuel value =) $1.17 per gallon of the oil that is incinerated in approved PCB incinerators.

The discussion of reclamation of used transformer oil concluded that the value of reclaimed oil was such that testing of batches of oil to demonstrate that the PCB content is below 50 ppm will be justified for most of the transformer repair shops. The oil that will require disposal will be those batches found to be contaminated above 50 ppm, that oil which has degraded past the point where reclamation is feasible, and the oil generated in small batches by junk yards and other industrial concerns that handle transformers infrequently. It was estimated above that 5.7 million gallons per year of available oil would be salvageable and contain less than 50 ppm PCBs.

*Letter from James Thompson (T&R Electric Supply Company, Inc.) to EPA dated August 28, 1978.

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The maximum economic cost would be incurred if the remaining oil were disposed of in approved high temperature PCB incinerators. The total annual cost of this incineration is calculated in Table 6.3-3 to be $11.1 million per year. This total would be reduced considerably if the large utilities were willing to accept contaminated oil for burning in high efficiency boilers from other sources, but the comments to the EPA by the utilities did not express any interest in making this service generally available.

The willingness of large utilities to make available their high efficiency boilers for burning used transformer oil may be increased by the willingness of the small utilities and transformer repair shops to pay up to $.75 per gallon for this service. The large utilities would incur no cost other than the cost of supervising the transfer of truck loads of liquids to their storage tanks and the monitoring and record keeping costs that are incurred by the regulations on any disposal of PCBs. Given a perfect market, the large utilities might be expected to be willing to pay for the fuel value of the used oil. However, the market is likely to be very imperfect, and the actual price charged by the utilities for this service can therefore not be predicted. However, since the burning of oil by the large utilities will not cost them anything, the price that is charged will represent a transfer payment from the small transformer shops and distribution utilities to the large utilities, and will not represent a real economic cost. Real economic costs would result only from the higher transportation costs of moving the oil to the large utilities and from the greater value of the heat content of the oil to the smaller companies than to the large utilities. These economic costs are likely to be only a small fraction of the costs incurred by incineration of this oil in approved PCB incinerators.

Marking and Storage Costs: The change in the definition of PCB material from a concentration of 500 ppm to a concentration of 50 ppm extends the impact of the PCB Marking and Disposal Regulations to all used

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TABLE 6.3-3

Cost of Disposal of Transformer Oil from
Small Utilities, Transformer Repair Shops, and Other Sources

	Total Amount of Transformer Oil in Service	1.7 billion gal.
x	Amount Available Each Year	4%
x	Amount Not Owned by Large Utilities	22%
=	Amount Available Per Year	15.2 million gal.
-	Amount Reclaimed and less than 50 ppm PCBs	5.7 million gal.
=	Total Available for Fuel	9.5 million gal.
x	Cost of Incineration and Lost Fuel Value	$1.17 per gal.
=	Maximum Cost Per Year:	$11.1 million per year

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transformer oil that is being stored for disposal or reuse and to the oil that is being transported for disposal. At a very minimum, special PCB storage areas will be required at each of the 149 large utilities that maintain their own transformers. These major storage areas were previously estimated to cost $2000 to construct and to result in annual operating costs of $2,125 per year (Versar, 1977, pp. 2-6). Total costs incurred because of the inclusion of transformer oil may therefore be equal to ($2000 per site x 149 locations =) $300,000 in initial construction costs and ($2125 x 149 =) $320,000 per year thereafter. The regulation also permits bulk storage of used transformer oil and the provisions of the Spill Prevention Control and Countermeasure (SPCC) plans of the oil spill prevention program become the storage criteria. Since almost all utilities have SPCC plans, this option probably results in no additional costs being incurred.

Additional marking costs will be incurred in applying PCB labels to drums, tanks, and trucks used to transport used oil to the disposal sites. Because any tank used to contain transformer oil must be considered to be a PCB container, special decontamination will be required before it could be used for any other service. Therefore, it is likely that each high efficiency boiler facility will have a dedicated truck trailer tank that is used to haul PCBs. Application of labels to these tanks will cost only a few dollars per year.

6.4 PCBs Controlled by the Regulation

A certain amount of used transformer oil has been used in the past as fuel in various boilers and power generating units. When possible, the oil has been reclaimed for use in transformers. Other uses include road oiling and re-refining into lubricating oil. Only a very rough estimate can be made of the amount of PCBs released to the environment by past practices in handling used transformer oil.

If it is assumed that past practices resulted in the use of one-half of the oil as fuel in boilers operating at conditions that

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destroyed 98% of the PCBs present and that the remaining PCBs would eventually enter the environment, the burning would have been expected to destroy (.98 x .5 x 400,000 lb PCBs =) 196,000 pounds of the PCBs in transformer oil. The effect of the regulation is to require the eventual disposal of all transformer oil in high efficiency boilers that will destroy 99.9% of the PCBs present. Therefore, PCB releases to the environment may be reduced from (400,000 - 196,000 =) 204,000 pounds to (400,000 x [1 - .999] =) 400 pounds, or a net reduction of about 200,000 pounds of PCBs.

6.5 Summary - Economic Impacts:

Ban on reclaiming oil for resale:	$3.2 million to $5.6 million per year (may be reduced if EPA exempts processing and resale from the ban requirements).
Limitations on disposal of contaminated transformer oil:	
Cost of storage tanks, etc., at high efficiency boilers:	cannot be estimated from information in the record.
Cost of incinerating oil generated by other than large utilities:	Up to $11.1 million per year if large utilities do not accept oil for burning in their boilers. Cost may be reduced considerably if large utilities make this service available.
Cost of special storage area for transformer oil at utilities:	$0 to $300,000 initially plus $0 to $320,000 per year starting 30 days after promulgation of the regulation.

6.6 Cost Per Pound of PCBs Kept from the Environment

If it is assumed that the restrictions on disposal and reclaiming of transformer oil will continue for the 30 year life of the newest oil filled tranformers:

Ban on reclaiming and special disposal requirements =

$$\frac{\$3.2 \text{ million to } \$5.6 \text{ million} + 0 \text{ to } \$11.1 \text{ million} + 0 \text{ to } \$.3 \text{ million}}{200{,}000 \text{ lbs}/30 \text{ years}} = \$480 \text{ to } \$2550 \text{ per pound PCBs}$$

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7.0 IMPACTS ON TRANSFORMER SERVICE COMPANIES

7.1 Present Status

There are presently about 300 small companies that service the transformers owned by small utilities and by industry.* The services offered by these companies include field testing and servicing of transformers and complete shop maintenance and rebuilding services.

7.2 Requirements of the Regulation

The regulation requires that all oil-filled transformers be considered to be PCB contaminated transformers unless the concentration of PCBs in the oil has been demonstrated by chemical analysis to be less than 50 ppm. The regulation bans the sale of any new or reclaimed transformer liquids unless they are known to contain less than 50 ppm PCBs.

7.3 Impact of the Regulation

The major impact of the regulation on the small transformer service companies results from the change in the definition of PCBs from a concentration level of 500 ppm to a level of 50 ppm. Many of these companies have discontinued servicing askarel transformers because of the potential liability that could result from spills or worker exposure, and because of the relatively high price of building the required storage areas for PCB materials. Companies who do not have oil storage facilities meeting SPCC requirements are now required to install special storage areas for the storage of oil filled transformers and used transformer oil.

Transformer service companies will face increased costs from the ban on reclaiming PCB contaminated transformer oil for resale, and

*Letter from Robert L. Sandman (Electric Apparatus Service Association) to EPA. Undated.

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increased disposal costs. These costs were discussed in detail in Chapter 6, and the companies should be able to pass them along to their customers. The fact that the regulation allows reclamation of PCB contaminated oil for use in the owner's transformers but not for resale will provide an economic incentive for utilities and large industrial concerns to perform their own maintenance rather than contract it out. However, there is not sufficient information available to support any quantitative estimate of the resulting market shifts. The economic impact of restrictions on these activities will be dependent on the extent to which EPA grants exemptions for these activities.

7.4 PCBs Controlled by the Regulation

There was no information presented on the amount of PCBs entering the environment as the result of improper storage of transformer oil by transformer service shops. Therefore, no estimate can be made of the reduction of PCBs entering the environment that will result from the improvement of storage conditions at these facilities.

7.5 Summary - Economic Impacts

Information is not available from the record to make estimates of these impacts.

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8.0 MINING MACHINERY*

8.1 Current Use of PCB-Cooled Mining Machinery Motors

In the late 1960s and early 1970s, PCBs were used as a motor coolant in three types of electric motors manufactured by Reliance Electric for Joy Manufacturing Company. Joy used these motors in three models of low seam mining machinery: CU43 continuous miners, 9CM continuous miners, and 14BU10 loaders. Table 8.1-1 summarizes the production statistics and present usage of these machines.

One small coal mining company in Pennsylvania is operating the three remaining Model CU43 continuous miners known to be in service. This company also has portions of several other CU43 miners which they have purchased for parts. Two of the machines in use have had the PCB-coolant replaced with a silicone fluid and two of the three motors on the third miner have also been filled with silicone. If the motors were not completely cleaned and rewound at the time the silicone fluid was introduced, it is probable that the motors still contain low levels of PCBs. For the purposes of this analysis, it will be assumed that they are contaminated with PCBs at levels in excess of 50 ppm. Fifty-four of the fifty-seven 9CM continuous miners sold in the United States were located by Versar during the course of a telephone survey. Two of the three machines which could not be located were recently sold on the used-machinery market. It is assumed that these two machines are still in use. Thirty-five of the model 9CM miners are currently idle, fifteen are being used to mine coal, three are in use for maintenance or construction, two are in use on spare sections, and one is being used in a training program at a vocational school.

The 14BU10 loaders were originally sold to eighty-eight different mining operations, the majority of them small; sixty of these mines have three or fewer of these loaders. Based upon the expected service life of the machines and a survey of thirty-six mines, it is estimated that essentially all of these loaders are still in service.

*All figures and information in this Chapter are from Versar, 1978, except where noted.

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Table 8.1-1 Use of PCB-Cooled Electric Motors in Mining Machinery[1]

Machine	Number Produced	Number Still in Service with PCB Motors	Number of PCB Motors per Machine	Total PCB Motors	Number of Gallons of PCBs per Motor	Total Gallons of PCB per Machine	Total Gallons PCB
CM3 Continuous Miner	17	3	3	9	4	12	36
9CM Continuous Miner	57	15 + 6 [3]	3	63	5	15	315
14BU10 Loader	533[2] + 34 Spare Motors	250 [4] + 17 [5]	2	517	4	8	2,068

(1) Except as noted in (3) and (4) below, all data is from Varner, 1978.

(2) Approximately 280 of these machines now have air-cooled motors.

(3) 15 in use for production, 6 for other uses

(4) Oral Comments of Mr. A. R. Benvenuto (Joy Manufacturing Company) at the PCB Ban Regulation Hearings, August 25, 1978.

(5) Estimated, based on percentage of loaders that have been converted.

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For the past few years, Joy has been converting the motors on the loaders to air-cooling. As shown in Table 8.1-1, there are approximately 250 loaders and 17 spare motors that still contain PCBs.

The motors on the continuous miners and the loaders require occasional topping-off with additional fluid at the mines. The amount of fluid which is required is small but is necessary for the continued operation of the machines.

8.2 Requirements of the Regulations

The PCB Ban Regulations require or permit the following with respect to the continued use and servicing of PCB-cooled mining machinery motors:

- PCBs may be used in mining equipment until January 1, 1982.
- PCBs may be added to mining equipment motors at the mines until January 1, 1982.
- PCB motors in the loaders must be rebuilt as non-PCB cooled motors whenever the motors are returned to a service shop for servicing.
- PCB motors on continuous miners may be rebuilt as PCB motors until January 1, 1980.
- Any PCBs used to service or repair PCB-cooled motors must be stored in accordance with the storage for disposal requirements of Annex III (§761.42).
- Processing and distribution in commerce of PCBs for purposes of servicing mining equipment is permitted after July 1, 1979, for persons who are granted an exemption under TSCA §6(e)(3)(B).

8.3 Compliance Costs

Continuous Miners: The regulations allow rebuilding of the motors in the two models of Joy continuous miners as PCB motors until July 1, 1979. This deadline could be extended to January 1, 1980, if EPA grants the service shops an exemption from the "processing" and "distribution in

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commerce" bans. There are no non-PCB motors that can be used in place of the PCB motors on the continuous miners, and space limitations on the machines prevent converting these motors to air cooling. Since the PCB motors on the continuous miners require rebuilding after about 12 months of service*, all of these machines will have to be retired from use within about a year after the effective date of the ban on rebuilding the motors.

Because of the time limits in the authorization, the market for used 9CM and CU43 continuous miners will virtually disappear. Though this machinery may be technologically obsolete before January 1, 1982, there are undoubtedly numerous small firms which cannot afford the capital investment required for new machinery and thus rely on older used machines to fill their needs. In addition, larger firms often use older machinery for spare equipment or in mine construction. Therefore, the owners will be confronted with equipment that they must retire prematurely, losing the remainder of the machine's useful life or the income that could result from the sale of the machinery.

Eight companies still use 9CM or CU43 continuous miners for coal production. Six of these companies are relatively small, with production ranging from 0.7 to 4.2 million tons per year. The other two are large conglomerates with much higher annual productions. In addition, six machines are performing operations other than production. The market value of these machines is roughly $40,000 each (Versar, 1978). Table 8.3-1 summarizes the costs that would be incurred by each of the companies that still use the continuous miners for coal production. Table 8.3-1 omits the 42 miners that are idle or in non-production uses because the percentage of those miners that have any value is not known. If each of them has a value

*Testimony of Mr. Ed Warner (Joy Manufacturing Co.) at the EPA PCB Hearings, Chicago, Illinois, July 19, 1977.

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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*	3	0	$ 120,000
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
(Other Uses)		6	$ 240,000
TOTAL	3	21	$ 960,000

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

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of $40,000, the additional cost could be as much as $1.7 million. In no case does the economic impact exceed one percent of the value of the coal mined annually by any of the affected companies. It is assumed that replacement machinery could be obtained in time to prevent any interruptions in coal production.

Loaders: The PCB motors used on the loading machines can be converted to air cooling at a cost of $3,100 per motor. The motors usually require rebuilding after 18 to 24 months of service*, so most of the motors will be available for this conversion without incurring additional downtime for the machines. Joy Manufacturing Company has stated that its service shop has the capacity to convert all of the PCB motors presently used on loaders to air cooling by the end of 1981. Since the PCBs will be removed from these motors for purposes of disposal, this activity is not affected by the ban on "processing" of PCBs.

The total cost to convert the 517 PCB motors used on the loaders will be (517 x $3,100 =) $1.6 million. There should be no interruption of coal production due to the conversion program because PCB motors will be allowed to continue in use until January 1, 1982, and most of the conversions will occur when the motors will require normal rebuilding. It is anticipated that maintenance requirements will be greater for the air cooled motors than for the PCB cooled motors, but it is not possible to estimate the total economic impact of the resulting increased maintenance costs.

Storage Costs: Each mine would be required to store PCBs used for maintenance in a storage area that meets the requirements of Annex III. Joy sells the PCBs in one gallon cans. A non-leaking 55 gallon drum protected from the rain would meet the requirements of Annex III and would be of sufficient size to store all the PCBs any mine would require. Each of the 96 companies possibly involved (88 loader owners and 8 continuous miner owners) would need such a storage area. The cost for a barrel and a

*Testimony of Mr. Ed Warner (Joy Manufacturing Company) at the EPA PCB Hearings, Chicago, Illinois, July 19, 1977.

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label may amount to $50 each for a total cost of $4,800. The recordkeeping required for storage areas may increase this cost by a factor of two to three, for a maximum expected cost of $14,400.

Exemption Application: It is assumed that Joy Manufacturing will apply for an exemption under TSCA §6(e)(3)(B) in order to be allowed to rebuild the loader motors and to be allowed to distribute PCBs to the mines for maintenance. The estimated $1,600 cost of preparing this petition is developed in the chapter on unintentional product contaminants.

8.4 PCBs Controlled by the Regulation

The electric motors in use on mining machines contain about 2419 gallons of PCBs (Table 8.1-1). This is equivalent to about 27,500 pounds of PCBs with a density of 11.37 pounds per gallon. The regulations will stop the losses of PCBs from these motors by requiring that they be scrapped or rebuilt as air cooled motors by January 1, 1982. There is no information in the record on which to base any estimate of the rate at which PCBs are lost from these motors. Therefore, no estimate can be made of the number of pounds of PCBs that will be prevented from entering the environment.

8.5 Summary-Economic Impacts

Loaders - rebuild motors @$3,100	$1,600,000
Continuous Miners-premature scrapping of 24 operating machines @$40,000	960,000
42 other miners @0 - $40,000	0 to 1,700,000
Storage costs - 96 storage areas	14,400
Exemption application	1,600
TOTAL	$2,576,000

(plus up to $1,700,000 for idle miners)

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8.6 Cost Per Pound of PCBs Kept from the Environment

If it is assumed that the regulation will prevent the entry into the environment of all the PCBs presently in use, and that all of the PCBs would otherwise be lost:

$$\text{Cost per pound} = \frac{\$2,576,000 \text{ to } \$4,276,000}{27,500 \text{ pounds}} = \$94 \text{ to } \$155 \text{ per pound PCBs}$$

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9.0 ELECTROMAGNETS*

9.1 Current Usage

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 PCB based askarel liquid. 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 transformers. Those leaks that 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. Since the magnets are suspended over conveyor belts, diking is not feasible, and any leakage would be uncontrolled. However, PCBs dripping onto the coal would be expected to be destroyed in power generating boilers, thus making the only loss to the environment that of leachate from contaminated coal in storage piles. The total amount of PCBs presently in use in electromagnets is probably (200 magnets x 135 gallons per magnet x 11 pounds per gallon x .7 pound PCB per pound askarel =) 207,900 pounds of PCBs.

*All information in this chapter is from Versar, 1978, Chapter 9, except as noted.

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9.2 Requirements of the PCB Ban Regulations

Continued use: PCB-filled electromagnets are defined as a totally enclosed use of PCBs and therefore may continue to be used indefinitely.

Servicing: Minor servicing which does not require the removal of the coil from the casing is authorized until July 1, 1984. Removal of the coils is prohibited.

Sale of PCBs: Banned after July 1, 1979, unless EPA grants an exemption from the "distribution in commerce" ban.

Reclaiming PCBs: For reuse by the owner of the PCB transformer or electromagnet: authorized. For sale: banned unless an exemption is granted by EPA.

Disposal: By incineration in an approved high temperature PCB incinerator. Drained PCB electromagnets may be disposed of in approved chemical waste landfills; the liquids drained from the magnets must be incinerated in approved incinerators.

9.3 Cost Impacts of the PCB Ban Regulations

Continued use: The regulations impose no additional requirements beyond the labeling previously required by the PCB Disposal and Marking Regulations (EPA, 1978a).

Ban on manufacture: The ban on the manufacture of new PCB magnets is not expected to have a significant impact on either the manufacturers or users of these magnets. According to the magnet manufacturers, the PCB electromagnets could be replaced with oil-filled units at an average cost of $8,000 per magnet. However, the use of mineral oil in these applications would significantly increase the fire risks. The manufacturers regularly furnish silicone-filled magnets for use where more effective fire resistant characteristics are required than those achievable with mineral oil. Such silicone-filled units are 40 to 50% more expensive

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