September 1978

POLYCHLORINATED BIPHENYLS

A Risk/Benefit Dilemma

Monsanto Company
St. Louis, Mo.

HISTORY AND BACKGROUND

The chemical structure of polychlorinated biphenyls (PCBs) has been known for nearly 100 years. Commercial production of the material was initiated in 1929 in response to the electrical industry's need for an improved dielectric insulating fluid which would also provide increased fire resistant benefits when used in transformers and capacitors.

Mineral oil, the only known alternate material for these applications, had stability and flammability problems that made it potentially hazardous. Power surges in electrical equipment can cause arcs. A sustained, high-energy arc can vaporize mineral oil to the point where the material will ignite. The unique properties of PCBs -- inertness, fire resistance and their ability as dielectric insulators to act as non-conductors of direct electric current -- made them ideally suited for those applications where high-voltage arcing could occur, and result in fires and/or explosions, damage to equipment and create hazards to people.

As the unique properties of this material became more fully understood, many additional uses were found. Their fire resistant nature made them an excellent choice for use in hydraulic

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and heat-transfer fluids. Their inertness imparted long-lasting qualities to lubricants. They also improved the waterproofing characteristics of surface coatings and offered similar and other benefits to the manufacturers of carbonless copy paper, printing inks, plasticizers and special adhesives.

PCBs, therefore, evolved as a truly unique class of chemicals which met important needs for both industry and society. It was within this framework that Monsanto and other producers developed a growing, worldwide business for these versatile products.

FIRST SIGNS OF ENVIRONMENTAL CONCERN

In the late 1960s, some 40 years after PCBs were introduced, the first signs of potential environmental problems turned up in two separate events -- one in Japan, the other in Sweden.

In 1968, about 1,000 people in Japan became ill from eating rice oil heavily contaminated with Japanese-produced PCBs as a result of an unfortunate industrial accident which has come to be known as the "Yusho Incident." A leak developed in processing equipment and went undetected, allowing the PCB to spill into the rice oil. Some news accounts have erroneously linked this incident with deaths, stillbirths and miscarriages. While, in fact, no such cases were actually attributed to the incident, those exposed to PCB-contaminated rice oil did experience dizzyness, nausea, loss of appetite, weakness and dermatological side effects. Infants, born to mothers who had been exposed during pregnancy, exhibited

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darkened skin at birth, however, in every case, this condition cleared within three months. It should be pointed out that the levels of PCB contamination in the "Yusho Incident" were in the two-to-three parts-per-thousand range (extremely high concentrations) while the levels being reported in fish and wildlife today are in the low parts-per-million and billion.

THE JAPANESE BAN

Primarily as a result of "Yusho," the Japanese Government announced, in 1971, a total ban on all PCB usage to become fully implemented by September of 1973. Monsanto and the U.S. electrical industry are often asked how Japan has been able to get along without PCBs in its electrical applications. It should be pointed out that the major uses for PCBs in Japan were in "open applications," particularly for carbonless paper. The Japanese power distribution industry, less advanced than the U.S. technically, had never actually gotten around to taking advantage of fire resistant transformers to the extent they have been used in this country. Most of their transformers were either using mineral oil or were dry-type units. The Japanese capacitor industry on the other hand was only in the beginning stage of converting its equipment to the more reliable PCB dielectrics when the ban was announced. Reliability standards for capacitors in the U.S. are much more stringent than they are in Japan or anywhere else in the world. So the Japanese ban really did not materially impact that country's electrical power distribution industry.

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THE SWEDISH FINDINGS

The other early sign of trouble was reported by a Swedish biologist, who, while using a new and totally unique technique, for the first time suggested the presence of PCBs in the bodies of fish. Monsanto and others began immediately to study the Swedish work. But before these findings could be confirmed or duplicated in the U.S., analytical methods had to be refined in order to separate PCBs from the other chlorinated hydrocarbons (like DDT) that were known to be present in the environment. Techniques also had to be developed to enable researchers to identify the chemicals in a very small (parts-per-billion) range.

MONSANTO'S RESTRICTED SALES PROGRAM

When scientific investigations first confirmed the presence of PCBs in the environment in the U.S. in 1970, and long before information regarding the potential impact of this contamination was determined, Monsanto voluntarily began a program to terminate sales of PCBs to open applications -- those which could likely result in losses to the environment.

Major applications affected by the company's unilateral withdrawal were in carbonless paper, fire resistant hydraulic fluids, heat transfer fluids and plasticizers. These restrictions resulted in a reduction in uses of PCBs, in applications where their loss to the environment was less controllable, of some 45 million pounds per year -- cutting production in half.

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At the same time, Monsanto made the conscious decision to continue supplying PCBs only to the electrical power distribution industry where they were marketed as dielectric fluids in "closed" or sealed systems such as transformers and capacitors.

In making this decision, Monsanto felt 1) That entry of PCBs to the environment would be effectively limited and controllable as a result of this restricted sales program (which became fully implemented by late 1972), 2) That a more biodegradable, lower chlorinated homolog had been developed for use by the capacitor industry, and 3) That withdrawal from electrical applications would have brought to a halt production of equipment, essential to the safe and efficient distribution and use of electrical energy (there being no known, satisfactory replacement for PCB dielectrics available).

MONSANTO'S MANUFACTURING FACILITY

In the manufacturing area we took a number of significant steps to prevent loss of PCBs to the environment.

These steps included literally making the department a "concrete bathtub." Drainage was collected in an isolated PCB sewer system with settling basins to insure PCB containment in case of accidental spill or equipment failure with the capability of monitoring the effluent from the department.

Storage tanks were blanketed with nitrogen to eliminate tank "breathing," and mist eliminators were installed in vapor lines to prevent PCBs from leaving the manufacturing area.

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STEPS TAKEN IN LABELING AND TRANSPORT PRACTICES

Monsanto shipped PCB fluids in both bulk carriers and in drums. Bulk shipments were made in a Monsanto-owned fleet of tank cars which were used exclusively for that service, or in customer-owned tank trucks. Drum shipments were made in special reinforced drums.

A multi-lingual warning label was affixed to each package giving a brief description of the nature of the material and appropriate actions to be taken in the event of a spill or leak. We also supplied a label to be used on return shipments for incineration, which gave similar information.

INDUSTRY GUIDELINES

Representatives of the transformer and capacitor industries, utilities and governmental agencies formed the American National Standards Institute Committee C-107 and promulgated guidelines for handling and disposing of dielectric fluids. The actions of that committee reflected the electrical industry's understanding of the need for proper control.

FEDERAL TASK FORCE

In 1972, Monsanto's voluntary program was reviewed by a Federal Interdepartment Task Force (consisting of representatives from the Office of Science and Technology, Council on Environmental Quality, Department of Agriculture, Department of Commerce, the EPA,

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HEW and the Department of the Interior). The Federal Task Force Report, which is a matter of public record, supported and endorsed Monsanto's program of restricted PCB sales.

MONSANTO'S RESTRICTED SALES PROGRAM

Prior to 1971, Monsanto sold some 85 million pounds of PCBs per year to literally thousands of customers, worldwide. Between 1971 and 1976, PCBs produced for U.S. consumption averaged about 27 million pounds per year and were used by fewer than 40 customers and only in the manufacture of sealed electrical equipment. Approximately 14 million pounds of PCBs were sold domestically during 1977, the last year of U.S. production by Monsanto.

Monsanto believes its actions effectively curbed the entry of PCBs into the environment, given the following facts:

1) Production - reduced by over 50 percent,
2) "Open-system" applications - totally eliminated,
3) Manufacturing controls (unique in the industry) - implemented, and
4) Stringent electrical industry guidelines (for handling and disposal) - established.

Monsanto's restricted sales program, together with an increased level of awareness and concern on the part of the electrical industry, had to have drastically reduced the amount of PCBs entering the environment. It is now known that certain of the PCB isomers

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will persist in the environment for a considerable period of time. Monsanto is convinced, therefore, that reports of widespread contamination are not evidence that the restrictions didn't work, but rather substantiation of the theory that old PCBs have remained in the environment and are now being increasingly identified by a growing number of researchers, equipped with improved, highly sophisticated analytical tools and armed with advance knowledge of what to look for.

And indeed, the findings of a task force involving agencies from Minnesota, Wisconsin and the Federal Government, organized in the spring of 1975, tend to support this theory. Their report, issued in November of 1975, said that industrial plants and sewage treatment facilities are not major sources of PCB contamination in the Mississippi River and its tributaries. Rather, the report suggested that the present source is quantities of PCBs that had been dumped into the river in past years. The report explained that these PCBs settled to the bottom and became lodged in the sediment -- only to be periodically stirred up by dredging operations.

Monsanto invested millions of dollars to implement and maintain its restrictive measures and controls and incurred significant additional costs when it terminated production and exited the business.

The company also expended substantial man-hours and considerable funds in major research programs aimed at developing environmentally compatible replacement fluids for the electrical

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industry. These programs were all shelved in early 1976 when it became apparent that the industry would eventually find a way, technically, to adapt existing, commodity-type compounds to their needs. The economic realities of this approach precluded any viable market potential for proprietary, specialty compounds like those being developed by Monsanto.

It now appears that the ongoing demand for fire resistant, liquid-cooled transformers will be satisfied by silicone compounds. Silicones are readily available from several manufacturing sources. In the capacitor segment, the trend is towards commodity-type solutions such as phthalate esters which are also manufactured by numerous firms.

MEDICAL IMPLICATIONS OF PCBs

The effects of trace amounts of PCBs in the environment is unknown. There is certainly no conclusive evidence that PCBs cause cancer. The National Cancer Institute recently completed a two-year PCB feeding study with rats. In a news release from the National Institute of Health (April 21, 1978), it was stated that according to a summary of that report the PCB material studied was not carcinogenic under the test conditions.

MONSANTO'S PHASEOUT/EXIT OF PCB BUSINESS

When Monsanto made the conscious decision back in 1970 to begin restricting sales of PCBs to close-system dielectric uses, the main reason we elected to continue supplying the electrical

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industry was that they had no viable alternates to turn to. This point was also recognized by the EPA. During a December 1975 press conference, EPA Administrator Russell Train said he would not ask Monsanto to stop production because that would shut down the electrical power industry and the railroads in short order. He said we must find a way to proceed without shutting down the country. That was precisely the position to which Monsanto had been committed to since 1970.

The problems involved with replacing PCBs were rooted in the unique fire resistant and dielectric characteristics of PCBs and the irreplaceable role they played in electrical and industrial applications for 45 years. The challenge facing the electrical industry was to replace them in an orderly manner without creating another hazard of equal or potentially greater magnitude while at the same time avoiding serious power and transportation disruptions.

In our October 5, 1976, press statement, Monsanto said it would complete distribution of all inventories and withdraw completely from the market as the principal supplier of PCB dielectric insulating fluids to the electrical power supply industry by no later than October 31, 1977. In making the announcement, Monsanto said the company would have targeted an even earlier shutdown date had transformer and capacitor manufacturers' conversion timetables permitted.

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All PCB production was halted by Monsanto in July 1977 and all customer shipments were completed by October 1977 from the company's Sauget, Illinois, plant.

PCBs continue to be manufactured by other firms in Germany, France, Spain, Italy and certain eastern European countries. No legislation prohibiting the manufacture or use of PCBs in closed systems exists in Europe.

REMOVAL OF PCBs FOUND IN THE ENVIRONMENT

Disposal of PCBs found in waterways is a very complex issue. There is no known technology that will guarantee 100 percent collection and disposal of PCBs from mud and silt bottoms.

Dredging is not a practical solution. Not only are costs extremely high, but more importantly the dredging operation itself recirculates PCBs, which have settled into the bottom materials, back into the waterway.

Presently, development of specific bacteria to break down the PCBs are under investigation at a number of laboratories including:

-- Ontario Foundation in Canada

-- Institute of Fermentation in Japan

-- General Electric's Schenectady Lab

Also a new method using high-energy electrons to destroy PCBs in water was reported by the Massachusetts Institute of Technology in November 1977.

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Monsanto has initiated research to identify innovational and practical approaches to the removal of PCBs from the environment. Such principles as absorption, extraction, new enzyme systems and other unconventional ideas will be explored through Monsanto research funding.

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