POLYCHLORINATED BIPHENYLS

A RISK/BENEFIT DILEMMA

MONSANTO COMPANY

ST. LOUIS, MO.

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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 a stability problem 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.

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It was further noted that when PCBs were used in these applications, they became a major factor in reducing the electrical current needed to serve the ever-increasing needs of industry and the public. The Electronic Industries Association (EIA) recently estimated that if PCBs were not available for these applications, the impact would require the expenditure of some $1 billion per year in additional electrical equipment and the consumption of about 68 million more barrels of oil annually, merely to produce the increased energy that less efficient materials would require.

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

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In 1968, about 1,000 people in Japan became ill from eating rice oil heavily contaminated with PCBs produced by a Japanese company in Japan as a result of an unfortunate industrial accident which has come to be known as the "Yoshu Incident." PCBs were being used as a heat-transfer fluid in equipment used to heat the rice oil. A leak developed in the equipment and went undetected, allowing the PCB to spill into the 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 dizziness, nausea, loss of appetite, weakness and dermatological side effects. Infants, born to mothers who had been exposed during pregnancy, exhibited 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 "Yoshu Incident" were in the parts-per-hundred range (extremely high concentrations) while the levels being reported in fish and wildlife today are in parts-per-million and billion.

THE JAPANESE BAN

Primarily as a result of "Yoshu," the Japanese Government announced, in 1971, a total ban on all PCB usage to become effective in 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,"

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particularly for carbonless paper. Japanese power distribution practices, being many years behind the U.S. technically, had never actually gotten around to taking advantage of fire resistant transformers to the extent they were used in this country. Most of their transformers were either using mineral oil or were dry-type units. The Japanese capacitor industry was in the process of converting its equipment to 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 impact that country's electrical power distribution industry all that much. It merely returned their electrical industry to the technology it had been using as standard practice only a few years earlier.

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 identified PCBs in the bodies of fish. Monsanto and others began immediately to study the Swedish work. But, before investigations could get underway 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.

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MONSANTO'S RESTRICTED SALES PROGRAM

When these 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 its program of terminating 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 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.

At the same time, Monsanto made the conscience decision to continue supplying PCBs only to the electrical power distribution industry where they were marketed under the Aroclor brand name 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 in late 1972, 2) that a more biodegradeable, 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

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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.

In our manufacturing area we took a number of significant steps to prevent loss of PCBs to the environment. Control, unique in the industrial chemicals industry, has been achieved. In addition, we have installed a special high-temperature incinerator which completely destroys spent PCBs by burning. This service and other technical assistance is available to our customers on a continuing basis.

In addition, representatives of the transformer and capacitor industries, utilities and governmental agencies have formed the American National Standards Institute Committee C-107 and promulgated guidelines for handling and disposing of dielectric fluids. The actions of this committee reflect the industry's understanding of the need for proper control.

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, 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.

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CURRENT SITUATION...MONSANTO'S POSITION

Thus, the situation today is drastically different from conditions which existed only a few years ago. Prior to 1971, Monsanto sold some 85 million pounds of PCBs per year to literally thousands of customers worldwide. At the present time, the 40 million pounds per year are used by less than 50 customers in the U.S. in the manufacture of sealed electrical equipment where safety and energy saving benefits, not otherwise obtainable, can be provided.

Monsanto feels that its current sales policy, together with increased awareness on the part of the electrical industry, has effectively controlled the entry of PCBs into the environment. We now know that certain of the PCB isomers will persist in the environment for a considerable period of time. A growing number of researchers and independent laboratories, equipped with improved, highly sophisticated analytical tools and armed with advance knowledge of what to look for, are today confirming the persistence of this material which, until the early 1970's, was being introduced into the environment in large quantities on a routine basis by people who, at that time, had no way of knowing what the future impact of those actions might be.

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

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in November of 1975, says that industrial plants and sewage treatment facilities are not major sources of PCB contamination in the Mississippi River and its tributaries. The report further suggested that large quantities of PCBs, dumped into the river in past years, settled to the bottom and lodged in the sediment, only to be stirred up periodically by dredging operations, allowing the PCBs to mix with the water all over again.

Monsanto's programs and its on-going research studies, aimed at developing acceptable replacement dielectric fluids, have already resulted in the expenditure of millions of dollars and our efforts will continue.

POTENTIAL REPLACEMENT FLUID FOR CAPACITORS

In a presentation given at an EPA-sponsored National Conference on Polychlorinated Biphenyls, held in Chicago in November of 1975, Monsanto revealed that capacitor manufacturers had been, for some time, evaluating sample quantities of a new dielectric insulating fluid, being groomed by the company as a potential replacement for PCBs. Development work on this project has been on-going for several years and was intensified at about the time Monsanto began withdrawing its PCBs from open system applications.

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The new candidate, code named MCS 1238, is based on Monsanto's proprietary technology in hydrocarbon chemistry and is described as a synthetic hydrocarbon mixture, with a high dielectric constant modifier added. MCS 1238 is designed to operate in all capacitors currently using PCBs...the dielectric properties of the new product so closely match those of PCBs that it will be possible to substitute one for the other with a minimum of redesign problems in the capacitors and the equipment using them.

Unlike PCBs, MCS 1238 is not a chlorinated product and, while much testing and confirmation work is still underway, initial environmental and toxicity results are encouraging. At the same time, this new fluid is not as fire resistant as PCBs. In our opinion any move to a non-PCB product, currently being investigated by any prospective manufacturer will represent a compromise or trade-off to some extent. In order to get improved environmental compatibility, society will have to give up some degree of fire safety.

Increased quantities of MCS 1238 will be made available as soon as possible from Monsanto's pilot plant for full-scale testing by U.S. capacitor manufacturers across their entire product lines. Subject to final industry acceptance and favorable long-term environmental test results, MCS 1238 could enter large scale production as early as January, 1977. In an average year, the capacitor industry consumes about 27 million pounds of Monsanto's 40-million-pound PCB production.

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TRANSFORMER CHALLENGES MORE FORMIDABLE

The remaining 13 million pounds is currently used by the transformer industry where development work is not nearly as far along on possible replacements. The same basic problems face anyone attempting to develop a replacement dielectric for transformers as for capacitors but fire resistance is even more essential in certain transformer applications for two basic reasons: 1) transformers contain about 2,000 pounds of dielectric fluid compared to an average of four ounces in a typical ballast-type capacitor, and 2) many of these 2,000-pound-units are found in high-rise buildings, hospitals, schools and urban commuter trains where a fire could well be catastrophic.

It is because of this that, despite the normal commercial pressures to replace it, PCBs have endured as the reference standard for fire resistance and reliability in transformers for over 45 years. To guide our research efforts in seeking acceptable replacements, standards need to be established, based on an objective evaluation of the fire hazards associated with the major sector of transformer use.

It is axiomatic that the chemistry which imparts fire resistance tends also to produce stable molecules that will persist in the environment. Our research efforts here are focused on developing

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replacement fluids that will provide performance reliability, an acceptable degree of fire protection and, at the same time, be environmentally acceptable. The challenge is formidable, indeed.

Monsanto has several candidates currently being readied for evaluation by the transformer industry. These materials are in a sufficiently early stage of development that any description of their makeup or performance characteristics would be premature at this time.

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