PCBs: A Perspective for the Die Casting Industry

Dr. John H. Craddock
Product & Environmental Safety Director
Monsanto Co., St. Louis, Missouri

Polychlorinated biphenyls (PCBs) have received considerable attention over the last 15 years because of concerns about their environmental persistence and their possible effects on human health and the environment. They are pervasive and misunderstood. PCBs have come to be among the chemicals most feared by many persons.

PCBs are now highly regulated. They are the only chemical substances singled out by Congress for "immediate" regulatory action under the Toxic Substances Control Act of 1976 (TSCA).[1] In July 1979, regulations covering the manufacture, distribution in commerce, use, marking, storage, and disposal of PCBs became effective in the U.S.[2]

For safety reasons, the die casting industry used PCBs in hydraulic fluids for many years. Because PCBs are relatively nonflammable, apparatus containing them is essentially free from fire and explosion hazards associated with usage near high temperature and open ignition sources. Thus, the die casting industry is particularly affected by the PCB regulations under TSCA.

This article will describe die casting industry use of fire-resistant hydraulic fluids containing PCBs, and the actions taken—both by industry and the government—after PCBs were discovered in the environment in the late 1960s. The article also will discuss the current federal PCB regulatory framework and the latest studies assessing the possible environmental and human health effects of PCBs.

History and Uses of PCBs[3]

PCBs are a class of organic chemicals known as chlorinated aromatic hydrocarbons. They were introduced into United States industry in 1929. Chemically, PCBs are composed of carbon, hydrogen and chlorine atoms in various combinations (see Figure).

The unique chemical and physical properties of PCBs led to their widespread use. PCBs are chemically inert, stable and fire resistant, and they have a low vapor pressure (BP ranges 275°-425°C). PCBs function uniquely as dielectric insulators to act as nonconductors of direct electric current. These properties made them ideally suited for electrical applications where high-voltage arcing could occur and could result in fires and/or explosions, damage to equipment, and significant hazards to health and life. Thus, since the early 1930s, PCBs have been used in transformers, capacitors, and other electrical equipment.

The fire-resistant nature of PCBs also made them well suited for use in hydraulic and heat transfer fluids. Industrial hydraulic operations began using PCBs for fire protection in the late 1940s and early 1950s. Usage increased in typical industrial applications where fire-resistant properties were both desirable and necessary. PCB hydraulic use concentrated in primary metal production and metalworking industries which utilized high temperatures and power usage for producing and forming metals and related products.

Hydraulic power is used extensively in the basic steel and aluminum industries, in foundries, and as the primary means of transmitting large forces in die casting, forging, and extrusion. Metal temperatures in or near hydraulic equipment for such uses range from 800 to 3000°F, and the fire hazard is severe.

In addition to fire safety, PCB hydraulic fluids offered additional performance characteristics such as lubricity, anti-rust and corrosion properties, and favorable physical properties; e.g., vapor pressure and viscosity, to facilitate equipment design and operation.

PCBs also were used in a variety of other industrial products, including items such as lubricants, inks, plasticizers, adhesives, coatings, and carbonless copy paper. However, the bulk of all PCB sales were for electrical, heat transfer, and hydraulic fluid applications.

Monsanto Co. entered the chlorinated biphenyl business in 1935 with the purchase of Swann Chemical Co., and eventually became the major producer of PCBs in the United States. PCBs also were produced in a number of other countries and are still produced and used in many European countries.

Growing Awareness of Potential Concerns

The use of PCBs resulted in industrially superior products. Because of their widespread use, they have been distributed throughout the environment. However, their persistent presence in the environment was unsuspected before the late 1960s.

Scientific knowledge about the presence of PCBs in the environment, and about its possible significance, began to evolve during the late 1960s. That evolutionary process began with two events, one in Sweden and the other in Japan.

In Sweden, Soren Jensen—using new analytical technology to investigate DDT residues in the environment—reported the possible presence of PCBs in fish tissue.[4] Following preliminary news media reports in late 1966, Monsanto and others began immediately to study the Swedish work. Before the findings could be confirmed or duplicated in the United States, analytical methods had to be refined in order definitively to separate PCBs from other chlorinated hydrocarbons that were known to be present in the environment. New techniques were required to enable researchers to detect and identify these chemicals in the trace-level ranges being reported. The advent and development of refined gas liquid chromatography analytical techniques, during this time period and since, have made routine

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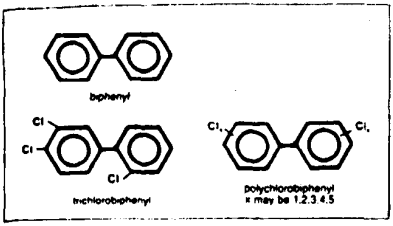

Figure showing chemical structure of typical PCB molecules.

analyses in the part per billion (ppb) range possible.

In western Japan in 1968, about 1000 people became ill as the result of an unfortunate industrial accident in which rice oil was contaminated with PCBs when a heat exchanger ruptured and leaked into the food product.[3] The illnesses—which came to be known as "Yusho," or rice oil disease—initially were blamed on the presence of PCBs. Several years later, however, it has been learned that most, if not all, of the toxic Yusho effects were not caused by the PCBs but were actually caused by extraordinarily high trace levels of impurities in the Japanese PCB fluid.

The presence of PCBs in the United States environment was confirmed by 1970, but little was known about their potential impact. Based on these early studies and reports, Monsanto voluntarily terminated sales of PCBs in 1970 for use in "open" applications, such as plasticizers and carbonless copy paper,[4] and also advised food processors using PCB heat transfer fluids to change to alternative heating methods. Monsanto re-emphasized the need for improved monitoring of finished food products to preclude contamination by any heat transfer fluid. In 1971, the company terminated all heat transfer fluid sales of PCBs, substituting other products with equivalent thermal stability but less fire resistance.

The development of replacement hydraulic fluids also began in 1970. In 1970 and 1971, Monsanto contacted customers in various industry segments, including the die casting and metals producing industries, who used PCB hydraulic fluids as well as other PCB formulations, to inform them of PCB environmental concerns. Monsanto alerted users of PCB hydraulic fluids to manage wastes in order to eliminate PCB discharges to the environment. As new hydraulic fluids were developed in 1971, sales of fluids containing PCBs were terminated.

The only uses for which Monsanto continued to produce and sell PCBs were certain enclosed applications in the electrical industry, such as in capacitors and transformers. No suitable replacements for PCB dielectric fluid were available in the early 1970s. The electrical industry and the government suggested that the benefits to society of continued chlorinated biphenyl dielectric use outweighed the low risk of uncontrolled releases from sealed applications. The government's Interdepartmental Task Force on PCBs recommended in their May 1972 report that "the use of PCBs should not be banned entirely. Their continued use for transformers and capacitors in the near future is considered necessary because of the significantly increased risk of fire and explosion and the disruption of electrical service which would result from a ban on PCB use."

The government requested that Monsanto continue producing PCBs for these applications, in order not to stop the production of equipment essential to the safe and efficient distribution and use of electrical energy. Therefore, Monsanto agreed to continue supplying PCB products to manufacturers of electrical power distribution equipment for use *only* in capacitors, transformers, and other sealed systems. In *continuing to sell to such customers, however,* Monsanto emphasized that the key to managing the risk was sound maintenance practice and disposal control. Monsanto also required assurances that the materials would be safely handled and properly disposed of.

By 1977, replacement dielectric fluids were available, and Monsanto halted all production of PCBs. (PCB manufacture and sales were finally prohibited in July 1979 by Federal regulations.)

Government Regulation of PCBs

In the fall of 1971, the federal government established an Interdepartmental Task Force on PCBs to study the environmental presence and health effects of PCBs.[5] Among the Task Force recommendations was passage of a federal statute to restrict use and distribution of PCBs and to collect information about their effects.

Congress passed the Toxic Substances Control Act (TSCA) in 1976.[6] The act singled out PCBs for regulation, and authorized EPA to promulgate rules governing the disposal, marking, manufacture, processing, distribution in commerce, and use of PCBs.

EPA's final PCB regulations, published in July 1979, are found in Title 40, Part 761 of the Code of Federal Regulations (CFR).[7] In summary, the provisions:

- Prohibit all manufacturing of PCBs unless specifically exempted by EPA.
- Prohibit processing, distribution in commerce, and use of PCBs except in a "totally enclosed manner."
- Authorize certain processing, distribution in commerce, and use of PCBs in a non-totally enclosed manner.
- Define marking, storage, and disposal rules.
- Define recordkeeping requirements.
- Establish a 50 parts per million (ppm) minimum PCB concentration for regulation.

Of particular interest to the die casting industry are those provisions of the regulations dealing with the use of PCBs in hydraulic systems, as well as the marking, storage, disposal, and recordkeeping regulations. Provisions dealing with uses of PCBs in electrical transformers and capacitors also may be applicable to the die casting industry.

The use of PCBs in hydraulic systems in a non-totally enclosed manner is specifically authorized until July 1, 1984, provided the conditions of 40 C.F.R. § 761.30(e) are met. These conditions require initial sampling and analysis of all hydraulic systems that *ever* contained PCBs . . . with subsequent flushing and draining of equipment. For each year that tests indicate a PCB concentration of at least 50 ppm, each hydraulic system must be drained and refilled with fluid containing less than 50 ppm PCBs. When the annual test indicates that the fluid in a system contains less than 50 ppm PCBs, no further testing is required.

Thus, the key checkpoint for hydraulic systems in the die casting industry is the 50 ppm minimum cutoff level. The required sampling, analysis, draining, and disposal of fluids—in addition to storage, marking, and recordkeeping requirements—are very expensive. In many cases, multiple drainings and flushings have failed to achieve PCB levels less than the 50 ppm regulatory cutoff level.

There is no known technology that will universally remove

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PCBs from hydraulic systems and will systematically achieve the required 50 ppm level by following a prescribed program. A major frustration of the industry is the failure to understand why simple dilution techniques such as multiple drainings and flushings with fresh fluid will not achieve the mathematically calculated reduced PCB levels.

The current regulatory scheme is complicated by a lawsuit brought by the Environmental Defense Fund (EDF) against EPA, challenging the validity of the 1979 PCB rules.[8] In a decision handed down in 1981, the United States Court of Appeals for the District of Columbia Circuit held that there was insufficient evidence to support certain provisions of the regulations authorizing "totally enclosed" uses of PCBs. The court also found the evidence insufficient to support the 50 ppm regulatory cutoff level.

The court directed EPA to develop new PCB regulations but allowed the 1979 regulations to stand until such time as new PCB rules are promulgated. Thus, EPA faces the task of establishing a new regulatory cutoff level and/or authorizing additional non-totally enclosed PCB uses at low PCB levels, such as in hydraulic systems containing low but measurable PCB levels. This rulemaking procedure is taking place at the present time.[9]

Health Effects of PCBs

Since Congress passed TSCA in 1976, much new scientific information has been published on the health effects of PCBs in both humans and animals. A search of the published literature indicated that over 5000 scientific and technical papers on PCBs have been published since 1976.[10]

Of particular significance are those reports relating to human exposure or epidemiology studies. Within the past two years, results of a number of published human PCB exposure-studies have shed significant new light on the PCB health effects issue.[11] In addition, two independent groups of scientists have recently re-reviewed the total body of PCB health and toxicity literature with particular emphasis on the human exposure studies.[12,13] These reviews have been in conjunction with the new EPA rulemaking procedure required by the Court of Appeals in the EDF case. The Chemical Manufacturers Association (CMA) sponsored one group of reviewers: Ecology and Environment, Inc. (E&E), an independent environmental consulting firm from Buffalo, NY. The E&E report—"Summary of the Health Effects of PCBs"[12]—was submitted to CMA and EPA in November 1981.

A second independent review of the PCB health effects and environmental effects literature was sponsored by trade associations in the utilities and electrical equipment industries, Edison Electric Institute (EEI) and the National Electrical Manufacturers Association (NEMA). The EEI/NEMA study was performed by Drill, Friess, Hays, Loomis and Shaffer, Inc., Consultants in Toxicology, Arlington, Va. The Drill, Friess et al report was submitted to EPA in February 1982.[13]

The independent conclusions of both of these groups of scientists, which are supportive of and consistent with each other, may be summarized as follows:[12,13]

1. Current exposures to PCBs generally do not pose any serious risk of injury to human health.
2. PCBs are not human carcinogens.
3. PCBs have not been shown to affect human reproduction adversely or to cause birth defects. PCBs are not mutagens or teratogens.
4. The only proven adverse human health effects resulting from PCBs are two skin conditions, dermatitis and chloracne, which are reversible after discontinuance of exposure.

Ecology and Environment, Inc. (E&E) concluded in their report submitted to EPA that "any exposure to PCBs' does not post a significant health risk to humans." E&E concluded "that PCBs do not represent a carcinogenic (genotoxic/initiator) risk and that, even if they possess oncogenic (epigenetic/promoting) activity, the risk at low exposures is insignificant."

Recent epidemiological studies also have failed to find any serious health effects caused by exposure to PCBs. A 1981 study by the National Institute of Occupational Safety and Health (NIOSH) focused on 2500 electrical equipment manufacturing workers[14] who had been occupationally exposed to PCBs for several years. Many of the workers were routinely exposed to PCBs for over 10 years. The study found no excess in total mortality or in mortality due to cancer, cardiovascular disease, or neurological disorders.

A recent review (by Dr. William Gaffey of Monsanto Co.) of epidemiology studies published to date found that during occupational exposure, PCBs can cause temporary skin problems, but that there were no clinically observable long-term human health effects, including the occurrence of cancer." Studies of non-occupationally exposed populations found neither dermatitis nor other clinical evidence of exposure-related effects.

Many of the recent epidemiology studies include data on large numbers of industrial workers who were occupationally exposed to PCBs over many years. In most cases, these were chronic occupational exposure to PCBs at levels far greater



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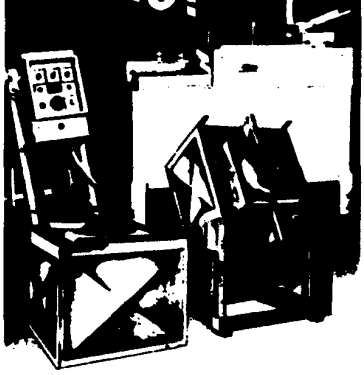

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than any reasonably foreseeable exposure level under existing regulations. The studies have shown that, like other chemicals, PCBs can cause dermatitis and chloracne, although these skin disorders are reversible after discontinuing exposure. In spite of over 50 years of PCB use, no causal relationship has been established for any specific type of cancer, nor has it been proven that the incidence of cancer mortality has increased due to PCB exposure.

Environmental Levels of PCBs

Recent measurements of environmental levels do not support the conclusion that PCBs have exhibited a significant irreversible impact on the ecosystem. In May 1983, EPA released the results of a study showing "a sharp decline in the percentage of the U.S. population having levels of polychlorinated biphenyls (PCBs) above three parts per million in their fat tissue."[15] The study continued:

> Results of the National Human Adipose Tissue Survey (NHATS) conducted by the Office of Toxic Substances indicates that the estimated fraction of the national population having greater than 3 ppm of PCBs has decreased from 8 to 1 percent between 1977 and 1981 after increasing from 2.7 to 8 percent between 1972 and 1977. This indicates that exposure of the U.S. population to PCBs is decreasing.

Data on PCB contamination of fish and natural bodies of water have shown that environmental levels are still decreasing at a significant rate. Levels in fish in three different areas of the United States (Great Lakes,[illegible] New York,[illegible] and Alabama-Georgia[illegible]) were in the range of 1 to 5 ppm in 1980-81, as contrasted with levels ranging from 60 ppm in 1973 to 18 ppm in 1975.

In addition, recent publications have demonstrated that the more highly chlorinated PCB homologs are not as persistent as predicted. Although their persistence had been predicted to be on the order of 100 years, one study has shown that their average persistence is in the range of 40-50 months.[illegible] The findings are based upon half-life values of PCBs in the tissues of environmentally exposed fish.

Data published by the National Academy of Sciences in 1979[illegible] also shows a significant reduction of PCB concentrations in the air over the North Atlantic Ocean. The data demonstrates an order of magnitude decrease in PCB concentrations in the air ranging from 0.76 ng/m ($\pm$ 0.55 ng/m) in 1973 to 0.074 ng/m ($\pm$ 0.099 ng/m) in 1977.

The downward PCB trends are the result of voluntary industry actions taken in the 1970s to reduce usage of and possible exposure to PCBs. These responsible industry actions were taken before the enactment of TSCA in 1976 and far earlier than the actual PCB regulations in 1979.

Summary

Recent studies indicate that PCBs are not human carcinogens and that while they may produce reversible skin conditions, they do not pose serious risk of injury to human health. Also, as a result of voluntary efforts to reduce the use of PCBs, the level of PCBs in the environment continues to decrease.

To preserve and continue these environmental improvements, the die casting industry must continue to use special care in the handling of any item containing PCB, including hydraulic machinery, capacitors, and transformers. Good industrial hygiene work practices should be employed by all workers who may come into contact with PCBs.

Although the regulatory environment governing PCBs is

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in a state of flux, regulations are in effect governing a aspects of the use, distribution in commerce, and disposal equipment containing more than 50 ppm PCBs. These regulations are detailed . . . and require the die casting industry continue to reduce the concentration of PCBs in hydraul fluids.

References

1. Toxic Substances Control Act of 1976. Public Law 94-469. Oct 1976.
2. U.S. EPA. Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce and use Prohibitions—U.S. Code Federal Regulations, 40 C.F.R. 761 as published in *Federal Register* p. 31514-31568, May 31, 1979.
3. Hutzinger, O. et al. *The Chemistry of PCBs*. CRC Press, Inc., Boca Raton, Florida, 1974.
4. Jensen, Soren. "Report of a New Chemical Hazard." *New Scientist* 612 (1966).
5. Sachi, S. et al. *Fukuoka Acta Med.*—62, 20 (1971). *Chemical Abstracts* 74, 146294 (1971).
6. Versar, Inc. (consultants). "PCBs in the United States—Industrial U and Environmental Use"—U.S. EPA Final Report, EPA 560/6-76-00 Feb. 25, 1976, p. 2.
7. Interdepartmental Task Force on PCBs. "Polychlorinated Biphenyls and the Environment." May 1972, Washington, D.C., National Technical Information Service COM-72-10419, Springfield, Va.
8. *Environmental Defense Fund vs. Environmental Protection Agency*, 636 F.2d 1267 (D.C. Circuit 1980).
9. Anonymous. "The Specter of Tougher PCB Rules." *Chemical We* Jan. 14, 1981, p. 49.
10. Chemical Manufacturers Association (CMA). "Comments in Respo to Two Advance Notices of Proposed Rulemaking Relating to Manufacture of PCBs Below 50 Parts per Million," published May 1981, by the Environmental Protection Agency (46 Federal R 27617, 27630). Submitted to U.S. EPA Nov. 25, 1981. EPA Docket OPTS-62013 and OPTS-62014.
11. Gaffey, W. R., "The Epidemiology of PCBs"—Presented at th American Chemical Society National Meeting, Div. of Chem Health and Safety, Symposium on Epidemiology, August 1981. abstract paper 46.
12. Biology and Environment, Inc. (consultants). "Summary of the He Effects of PCBs," prepared for the Chemical Manufacturers Asso ciation, November 1981 (submitted to U.S. EPA November 1981 Reference 10).
13. Drill, Priess, Hays, Lennie & Shaffer, Inc. (Consultants in Toxicology). "Potential Health Effects in the Humans from Exposure to P chlorinated Biphenyls (PCBs) and Related Impurities," prepared for Utility Solid Waste Activities Group, The Edison Electric Institute Jan. 25, 1982 (submitted to U.S. EPA Feb. 12, 1982).
14. Brown, D. P. and Jones, M., "Mortality and Industrial Hygien Workers Exposed to Polychlorinated Biphenyls"—*Arch. Environmental Health* 36, 120-129 (1981).
15. Lucas, M. et al. "Polychlorinated Biphenyls in Human Adip Tissue and Mother's Milk," Research Triangle Institute, North Ca lina, Nov. 12, 1982 (RTI/1864-59-03F), prepared for the U.S. National Human Adipose Tissue Survey (NHATS). Released by EPA, May 9, 1983 Washington, D.C.
16. Anonymous. "PCBs: They'll Be with Us Awhile," National Resou Register, vol. 2, January 1982, p. 8-9, published by Michigan Dep ment of Natural Resources, Lansing, Mich.
17. Linda Weisner, "PCBs in Fish: The Worst May Be Over," Great L Commentaries, vol. 11, December 1980, p. 3, published by the G Lakes Basin Commission.
18. J. McGuire et al. "1980 Report on Great Lakes Water Quality," G Lakes Water Quality Board Report to the International Joint Com sion—Canada and the United States, Nov. 13, 1980, Toronto, C Canada.
19. R. Armstrong and R. Sloan, "Trend in Levels of Several Ke Chemical Contaminants in Fish from New York State Water," New State Department of Environmental Conservation, Technical Re 80-2.
20. Anonymous, "Research on PCBs in Aquatic Ecosystems," SFI Bul 302, March 1979, p. 1-2, published by The Sport Fishing Inst Washington, D.C.
21. Committee on the Assessment of Polychlorinated Biphenyls Environment, "Polychlorinated Biphenyls," National Academ Sciences, Washington, D.C. (1979).

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