
POLYCHLORINATED BIPHENYLS IN VESSELS

Polychlorinated biphenyls (PCBs) are a class of synthetic organic chemicals consisting of from one to ten chlorine atoms (hence the *polychlorinated*) bonded to two joined six-member carbon rings (called a biphenyl molecule) that create up to 209 possible variations, or “congeners,” of polychlorinated biphenyls. PCB products are normally mixtures of several congeners adjusted by the manufacturer to impart specific bulk properties to the compound. The congeners with the least chlorine present are oily liquids. As the amount of chlorine in these liquids increases, the product becomes progressively thicker, up to a solid wax. The ability to vary the viscosity, coupled with other favorable industrial properties, made PCBs a broadly useful compound in industry and in many commercial products.

PCBs are not corrosive themselves and, unlike many other oils and waxes, are very resistant to decomposition into corrosive compounds. They also have a high heat capacity and a high boiling point, do not conduct electricity, are non-flammable, and have a very low acute toxicity. For these reasons, from the time they were first introduced in 1929, PCBs quickly became the standard coolant and dielectric in the electric utility industry and the preferred hydraulic and cooling fluid in all industries. They were used as coolant and dielectric in electrical transformers and high-capacity electric transmission cables, as dielectrics in capacitors and small transformers, and as hydraulic fluids and cutting oils in all manner of industrial machinery in virtually every nation of the world.

Their variable viscosity and the fact that they do not dry out and become hard almost regardless of their environment led to another use for PCBs: as plasticizers and sealing agents in products such as rubber and plastics (particularly in the ubiquitous polyvinyl chloride [PVC] plastic), adhesives, paints, inks, gaskets, sealing compounds, and carrier fluids for pesticides, and as a mounting fluid for microscope slides. Historically, about 60 percent of all PCBs produced were

used as dielectric fluids, about 12 percent as hydraulic and heat transfer fluids, and about 28 percent as ingredients in manufactured products.¹

Because PCBs are so common in the processing equipment of many product-manufacturing industries, many resulting products contain small amounts of PCBs picked up during their production. Examples include PCBs in extruded plastic and rubber products from use of PCB oil as an extrusion lubricant. Thus, PCBs can be found both as a functional and a tramp constituent of many products.

PCBs were manufactured in many countries: the United States (Monsanto was the only U.S. manufacturer), Austria, China, Czechoslovakia, France, Germany, Italy, Japan, the USSR and the Russian Federation, Spain, and the United Kingdom. Manufacturing stopped in the United States in 1979 but continued in many other countries well into the 1980s. Today, PCBs continue to be manufactured and exported for industrial use in some countries.²

Because PCBs are such chemically stable compounds, they do not degrade in the environment and they persist for decades, moving up the food chain by adsorption in lower life forms and ultimately in humans. PCBs can be found in trace amounts throughout the earth's biosphere, even in sediments on the bottom of the deepest oceans. They can be found in high concentrations in sediments and soils near places of their manufacture, use, and disposal. PCBs in human tissue are believed to be associated with an elevated risk of cancer and with other, noncancer abnormalities and are therefore coming under increasing regulation worldwide. While highly resistant to decomposition, PCBs are not immune. In a fire or at very high temperatures such as are seen in a kitchen frying pan, PCBs will decompose to, among other compounds, the extraordinarily toxic family of chemicals called dioxins.

PCB REGULATION

PCB regulation in the United States began in 1976 with the enactment of the Toxic Substances Control Act. This law and its implementing EPA regulations found at 40CFR761 led to a ban on the manufacture of PCBs in the United States in 1977 and to bans on imports, exports, and unrestricted use. In subsequent years, PCBs were gradually phased down in domestic industry but were not completely phased out.

¹*Guidelines for the Identification of PCBs and Materials Containing PCBs*, United Nations Environment Programme, First Issue, August 1999.

²"POPS Profile Information Reporting Form," Slovak Republic, UNEP Chemicals.

It was not until the mid-1980s and later that West European nations began to place restrictions on the manufacture and use of PCBs. For example, the United Kingdom initiated regulations in 1986, Finland in 1990. Some European and Asian countries continue to manufacture and use PCBs today. This continued use in many foreign countries appears to have led to incorporation of PCBs in domestic products from imported feedstock, presumably unbeknownst to U.S. manufacturers.

International regulation of PCBs is now the subject of discussions within the UN Environment Programme. This work began in 1998 and is directed toward development of a new international treaty that would ban or control the manufacture and use of PCBs and nine other chemicals.³ Although no agreement has yet been reached, notionally this work will lead to a ban on the continued manufacture of PCBs and to restrictions on the continued use of existing stocks, with the result that PCBs will ultimately disappear from the marketplace.

PCBs IN NAVY SHIPS

The Navy has followed the EPA's PCB regulations since they were first issued in the late 1970s. Consistent with the EPA regulations at the time, Navy actions focused on PCBs first in heavy electrical equipment (such as yard transformers ashore) and later on PCBs in small capacitors and transformers in shipboard electronic equipment.⁴ During the early years of PCB regulation, the Navy noted that a unique military lubricant and anti-foulant used on the cables of some naval mines contained a high concentration of PCBs as required by its military specification. This problem—believed to be the only case of a Navy product containing PCBs as required by a military specification—was addressed in the early 1980s. It was not until 1989 that the Navy discovered during the course of normal occupational safety work at a shipyard, that PCBs also occurred in many plastics, rubbers, adhesives, gaskets, and other commercial nonmetal products used in Navy ships. Similar PCB-bearing products were subsequently found in use in many non-Navy facilities and structures.

NAVSEA has been sampling for PCBs in Navy ships since the early 1990s. Sampling has been done to determine whether ships and craft to be disposed of contain PCBs that must be considered in the disposal process. Shipyards sample during maintenance on ships to determine whether the products removed during maintenance require handling as PCB-materials and to de-

³PCBs are one of ten "persistent organic pollutants," or POPs, that are the subject of future international regulation. Most of the other POPs are pesticides, e.g., DDT.

⁴With very few exceptions, Navy ships do not carry and never did carry large electrical transformers such as those used by electrical utilities and shore-based heavy industry sites.

termine whether work processes must be amended to accommodate the presence of PCBs. Data from this sampling process have been assembled by NAVSEA 00T into four databases. We analyzed these databases (current through May 2000) to estimate the frequency with which PCBs can be found in Navy ships. The results are shown in Table C.1.

Table C.1 shows that 28 percent of all retired Navy ships (see Appendix A, Table A.1) have been sampled in some manner for PCBs and that of these, 77 percent contain PCBs above 50 ppm in at least one material—the limit at which stringent regulation begins. Of the 113 Navy ships ready for disposal (category N8 in Table C.1), 50 have been sampled and all 50 were found to contain regulated levels of PCBs.

All of the 83 ships reportedly containing PCBs were sampled comprehensively for PCBs in liquids (hydraulic fluids and lubricants) and a variety of solid materials such as rubber, paint, and tape. Of the 25 sampled ships found with no PCBs, only two were sampled in the same manner. Twenty-three were sampled only for PCBs in liquids or for liquid PCBs on surfaces. PCBs are rarely found in shipboard liquids, probably because such liquids are frequently replaced during routine maintenance and PCB-free replacements have normally been used since the late 1970s. Thus, only two of 85 comprehensively sampled ships (or approximately 2 percent) revealed no regulated PCBs. What this means, thus, is that up to 98 percent of all the Navy ships awaiting disposal may contain regulated amounts of PCBs in solid materials.

Table C.1
Analysis of PCBs for Navy and MARAD Retired Ship Assets^a

Ship Category	Total No. of Ships in Category	Ships Sampled		With PCBs	
		No.	%	No.	%
N1: Navy mobilization and other retention assets	31	7	23	1	14
N2: Existing foreign military leases	26	0	0	N/A	N/A
N3: Potential future FMS and grants	39	8	21	3	38
N4: Potential donations or commercial leases	16	4	25	3	75
N5: Former Navy ships title-transferred to MARAD for disposition	87	24	28	14	58
N6: SINKEX candidates	9	6	67	5	83
N7: Held for spare parts	4	2	50	1	50
N8: Navy title vessels, ready for disposal, held at NISMFs or MARAD	113	50	44	50	100
N9: Special vessels	12	1	8	1	100
N10: Museum ships	51	6	10	5	83
Totals	388	108	28	83	77

^aThe complete list of ships is in Appendix A, Table A.1.

While the fact that PCBs are rarely found in shipboard fluids leads us to assume that newer ships may have less PCB material present than older ships do, there is not enough information in the databases for the ships in Table A.1 to validate this assumption. The newest ship listed in Table A.1 as having been sampled (and only for fluids) is *Shenandoah* (AD44), launched in 1982. No PCBs were found. The newest ship in which PCBs in solid materials were found is USS *Estocin* (FFG15), launched in 1979. The average launch date for the ships in Table A.1 is 1960.

PCBs IN MARAD SHIPS

In 1995, three MARAD ships in the ready-for-disposal inactive fleet were sampled comprehensively for PCBs and other hazardous materials: SS *Wayne Victory*, SS *Export Challenger*, and SS *Shirley Lykes*. PCBs were sampled in accordance with a then-new EPA shipboard sampling guide,⁵ and the results were published in a MARAD report and its many appendices.⁶ One of these appendices reported that PCBs were found in many different solid materials in the three ships but in none of the liquids.⁷

A sampling of three of the many MARAD ships in storage does not provide conclusive evidence for the presence or absence of PCBs in the MARAD ships listed in Table A.1. However, the fact that the three sampled MARAD ships revealed PCBs in the same types of materials that are used in Navy ships does indicate that the problem of shipboard PCBs is not unique to the Navy.

PCBs IN OTHER MERCHANT SHIPS

PCBs are regularly encountered during recycling of merchant ships. B. D. Ghosh reports up to 800 kilograms of PCBs in the paint of merchant ships recycled in India in recent years and also reports PCBs in electric cables and other materials.⁸ India's Ferrous Scrap Committee reports that there are PCBs in many materials in the commercial ships recycled at the Alang, India, yards but that none were found in the environment surrounding the yard.⁹

⁵Environmental Protection Agency, *Sampling Ships for PCBs Regulated for Disposal*, Interim Final Policy, November 30, 1995.

⁶MARAD, *Environmental Assessment of the Sale of National Defense Reserve Fleet Vessels for Scrapping*, Report MA-ENV-820-96003, July 1997.

⁷MARAD, *Survey of Ships and Materials*, Report MA-ENV-820-96003-F, January 1997.

⁸B. D. Ghosh, "Shipbreaking Industry in India: Present Status and Future Prospects," 1999, included as Appendix B in Ferrous Scrap Committee, Ministry of Steel, Government of India, *Shipbreaking in India, A Roadmap For Future Development*, undated (circa spring 1999).

⁹Ferrous Scrap Committee, Ministry of Steel, Government of India, *Shipbreaking Industry—Present Status in India and Its Impact on Environment*, Vol. I, August 1997.

Each year, recycling yards in India perform about 40 percent of all merchant ship recycling in the world. The average age of these ships is about 25 years, so most were built in the mid-1970s. All manner of merchant ships from a wide variety of ship operators and ship builders are recycled. The Ferrous Scrap Committee reports that PCBs are still in use in India and other countries but are being phased out at this time. The Committee thus expects the incidence of PCBs encountered during ship recycling to decline over the coming years.

THE COST OF MANAGING PCBs DURING RECYCLING

PCB management can be a notable cost in U.S. ship recycling because of the very strict rules that prohibit burning of PCB-bearing materials and require their disposal in specialized landfills. Ship recycling is a very labor-intensive operation, and the process of identifying and managing PCB-bearing materials can add significantly to the labor requirements.