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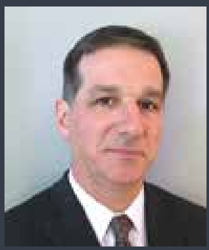

# The ABCs of PCBs

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It is not uncommon to encounter equipment and building components that may contain polychlorinated biphenyls (PCBs) when considering recognized environmental conditions (REC) for your Phase I Environmental Site Assessment. In fact, the potential for PCBs and PCB-containing equipment to be a REC is specifically called out in the American Society for Testing and Materials (ASTM International) E1527-13 “Standard Practice for Environmental Site Assessments.” But just what are these seemingly ubiquitous chemicals, and why do environmental professionals need to carefully address them in an ESA?

## Background and Need for Regulation

PCB oil has been used as a heat transfer media and in other industrial applications from approximately 1929 until 1979, when the U.S. banned PCB manufacturing and phased out most uses under the early days of TSCA, or Toxic Substances Control Act (US Environmental Protection Agency). Certain uses of PCBs are still authorized under TSCA, for example in transformers if PCB levels remain under 50 parts per million (ppm) or with restriction and regulatory requirements at higher concentrations. Lower allowable concentrations apply to manufacturing processes that may generate PCBs as a consequence of processes that involve hydrocarbons, chlorine, and heat.

Because PCBs have a high chemical and thermal stability, they can persist in the environment for decades. Their low solubility allows PCBs to bind strongly to soils and sediment and travel via surface water and groundwater. They also can become airborne. Once in the aquatic environment, PCBs are further transported by bio uptake from small organisms, and accumulate in the fatty tissues of higher organisms up the food chain, all the way to humans. PCBs that have been involved in combustion or high temperatures can form dioxins and furans, another class of toxic and persistent compounds. Whether by physical or biological transport, the extreme stability of PCBs allows them to be “re-emitted” and transported great distances for continued exposure. As further evidence of their persistence and distribution, PCBs have been detected in Arctic wildlife and ocean fish that are far from point sources (Agency for Toxic Substances and Disease Registry).

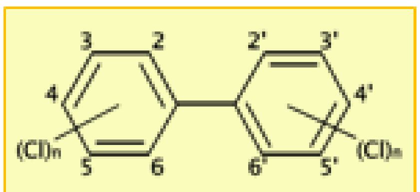

Figure 1: Basic polychlorinated biphenyl (PCB) chemical structure

**PCB Chemistry 101 –** The chemical properties of PCBs play a large role in their fate and transport in the environment and subsequent need for regulation. PCB chemical structure begins with two benzene rings (the biphenyl) having from one to ten chlorine atoms that substitute for a... ***(Continued on next page)***

hydrogen atom on the numbered positions of the biphenyl – see Figure 1. PCBs were manufactured in the U.S. by Monsanto Corporation under the trade name Arochlor. Each Arochlor is a complex mixture of chlorobiphenyls and is described by a four digit number.

The first two numbers, 10 or 12, indicate the carbon number; the last two numbers indicate the percent by weight of chlorine, where Arochlor 1254 for example contains 54% chlorine. The chlorine content causes PCBs to be either low-soluble liquids or even less soluble, sticky resins as the chlorine content increases. Other trade names or references to PCBs that may turn up in ESA research include Pyranol, manufactured by General Electric; Dow-Therm, a heat transfer fluid manufactured by Dow Chemical; and Therminol, a heat transfer fluid manufactured by Monsanto and containing Arochlor 1242. Many other trade names and commercial formulations can occur. A list of PCB manufacturers and trades names is available in the PCB Inspection Manual (US EPA, 2004). A partial list of trade names is shown in Table 1. This list provides a good starting point whereby if these names are identified on product or equipment labels or in facility records during a site visit, there is a good possibility that PCBs may have been used at the site or may still linger in products, equipment, or building materials. As cautioned in the EPA guidance, this list should not be assumed to be exhaustive or all-inclusive. If there is any doubt about whether an item of equipment contains PCBs, assume that it does.

When testing samples of oil or environmental media for PCB content, analytical laboratories can report a Total PCB concentration, or quantify the specific PCB number, known as a congener. This can allow a better understanding of the source and past use of PCBs that may have been released to the environment. Some of the more common PCB congeners detected are Arochlors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. The EPA analytical method (SW-846 8082) cites many more congeners to be reported. Further guidance exists when characterizing PCB releases to the environment, for example the National Oceanic and Atmospheric Administration (NOAA) method cites 20 congeners, and U.S. Army Corps of Engineers describes 22 congeners to be reported.

## How to Consider PCBs in a Phase I or Phase II ESA

The chemical properties and wide spread use of PCBs suggests that it would not be surprising to find them just about anywhere. The list of key PCB applications that should be considered in a thorough ESA is not infinite, but can be quite broad. A partial list follows.

**Electrical transformers –** Transformers are at the top of the list of PCB-containing equipment that is likely to be found in current or past use at a given facility. The PCB fluid is used for insulation, coolant and/or fire suppression. The facility or its power company can own or operate transformers, and would be responsible for upkeep and monitoring/reporting of PCB content and releases.

**Capacitors –** These are power-factor correction units similar to transformers that appear as rectangular boxes and may be located near high-power usage equipment like computer rooms and heating/cooling units. Non-PCB containing capacitors can be labeled as such, or have a manufacturer's nameplate that designates it is a "dry-type" and therefore are not as likely be a REC.

**Fluorescent light ballasts –** PCB-containing capacitors are also found in the box-like ballast or resin material associated with fluorescent light fixtures.

**Other electrical equipment –** PCBs can be found in switches, voltage regulators, circuit breakers, and oil-cooled electric motors. Oil-cooled electromagnets used in cranes for picking up metal and for metal separation in recycling may have PCBs. The nonmetallic recycled automobile material ("fluff") can have PCBs.

Ballasts in fluorescent lighting, especially before 1986 can be PCB-containing.

**Heat transfer fluids –** used in a wide variety of non-contact industrial cooling applications; and Hydraulic Fluids/Waste Oils such as would be used in elevator reservoir tanks.

**Plasticizers –** PCBs have been used as additives in polyvinyl chloride (PVC) plastic, neoprene, chlorinated rubber, laminating, adhesives, sealants, joint compounds, corrosion resistant paints, concrete, and other building materials. EPA has recently raised awareness that schools and other buildings constructed or renovated between 1950 and 1979 may have widespread occurrence of PCBs in caulk and other building materials.

PCBs that occur in building caulking may require specialized removal prior to demolition.

**Other applications of PCBs –** the list is not comprehensive, but PCBs and PCB-containing oils also have been used as spray for dust control; as an extender for the life of pesticides; in fire retardant coating; additives in printing inks; impurity in pentachlorophenol wood treating; and transfer agent for ink in carbonless copy paper (Source: ATSDR and others).

# CASE STUDIES

### It's OK to Keep PCB Transformers in Service, But…

There are conditions where a facility may continue to operate PCB-containing equipment. A former manufacturing plant that was being decommissioned had sixteen electrical transformers located in various substations around the building. During their use, the transformers had been retro-filled, whereby PCB containing fluids were drained and replaced with non-PCB oil. Remnant PCBs, due to their sticky nature, can remain on surfaces within the unit and become reintroduced into the new oil over time. As a result, retro-filling may need to be performed more than once, and continued periodic testing of transformer fluid is necessary to ensure PCB concentrations stay below 50 ppm. All active transformers at this particular facility continue to be serviced by an electrical contractor, and PCB test results are maintained in a sampling database.

A former textile plant elected to keep active PCB-containing electrical transformers that were deemed necessary to maintain the high power demand of the facility, but not without significant regulatory restrictions. The transformers each contain Pyranol, one of the fire resistant electrical insulating fluids identified by EPA (see Table 1) as containing PCBs. The fluid in these particular transformers was tested as having PCBs greater than 500 ppm, which classifies them as PCB Transformers. The current property owner is required to operate under an EPA Consent Agreement and Final Order of PCB regulations under TSCA. Consequences of the consent order have resulted in the owner being cited and fined for "uncontrolled discharges" of PCB fluids that were noted during an EPA inspection to have stains below the drain valves of two of the transformers. Under TSCA regulations, spills or leaks of such fluid constitutes illegal disposal of PCBs and is therefore subject to fines and civil penalties. The facility also violated TSCA regulations for improper storage of combustible materials, in this case a plastic trash can and an employee's shirt, within 5 meters of a PCB transformer enclosure. Monetary penalties for just these two incidents amounted to $13,700.

### Non-Transformer PCB Issues

A Phase I and II ESA at a school campus that was undergoing redevelopment identified four pad-mounted electrical transformers throughout the multi-building, approximate 50-acre complex. The transformers and associated pads, along with areas of stained soils, were removed by the local power company as part of their ownership and operating agreement for power easements. This left just confirmation soil sampling in the transformer vicinities, which confirmed there were no significant soil or groundwater impacts from leaking transformer fluids. The sampling efforts also were extended to several elevators to confirm hydraulic fluid reservoirs in each lift were not PCB-containing.

***(Continued on next page)***

It was other forms of PCB materials, however, that created response and cleanup needs for the property. While conducting asbestos, lead paint, and universal waste surveys for each of the buildings, the Phase II inventoried fluorescent light bulbs and associated ballasts that may contain regulated (> 50 ppm) amounts of PCBs, along with smoke alarms (radioactive materials) and thermostats (mercury switches).

Due to the sheer volume of light fixtures in the buildings, not all fluorescent units were disassembled to inspect the numerous varieties of ballasts and identifying labels for PCB content, but a representative percentage of units was sampled. To fully comply with TSCA, the Phase II also needed to assess presence of regulated PCBs in building materials for structures pending demolition. In addition to the light ballasts and elevator hydraulic fluids, representative samples were collected from applied paints and miscellaneous solid materials including glazing compound/caulking; roof sealants; non-conducting materials in electric cable insulation; gaskets in air handling systems; rubber and felt gaskets; thermal insulation material (including fiberglass, felt, foam and cork); sound deadening felt; and any other suspect materials where plasticizers may have been used. The school was originally developed in the early 1900s and had multiple renovations and additions into the 1980s, so the types and ages of building materials was diverse.

All bulk samples were analyzed by EPA Method 8082A, which can be used to quantify PCB content in solid, non-aqueous liquid/organic solid and aqueous liquid samples. This method determines concentrations of the common PCB Arochlors specified in EPA regulations. The quantitation of PCBs as Arochlors is appropriate for many regulatory compliance determination, but it may be difficult when the Arochlors have been weathered by long exposure to the environment, such as for exterior building caulks. When analyzing these materials, the 8082A method also provides a means to identify a selected group of the 209 possible PCB congeners, as another means to measure the concentrations of weathered Arochlors.

A total of 70 bulk samples were collected among seven buildings. Results showed that fluorescent light ballasts contained as high as 10,000 ppm of PCB, with the capacitor oils in some ballasts containing as much as 950,000 ppm, which is almost pure PCB. PCBs also were identified in building materials within four of the seven buildings, in general for those buildings with construction or renovation dates prior to 1980s. PCBs were detected in sealant caulk on roof perimeters and vents (up to 1,770 ppm); interior window frame caulk (up to 212 ppm); exterior window glazing (up to 74,500 ppm); exterior window caulk (up to 10,100 ppm); exterior paint on metal doors (up to 5,980 ppm); and exterior building caulks applied to various metal-to-glass or brick contact areas (up to 71,000 ppm). Response actions, performed under supervision of EPA, required removal and disposal of PCB-containing materials before proceeding with any other demolition work that would disturb or otherwise affect these materials. Because some exterior PCB-containing caulk, glazing, and paint had degraded and leached over time, non-PCB containing materials such as brick and mortar adjacent to the PCB-containing components, as well as soils immediately below some of the building components, also were found to have PCB concentrations that required removal and proper disposal.

| TABLE 1: List of Common Trade Names for Various Mixtures of PCB Oils (Source: US EPA) | | | | |
|---|---|---|---|---|
| Asbestol | Adkarel | Askeral | Auxol | Aceclor |
| Arochlor 1221, 1232/1248, 1254, 1260, 1268, 1270, 1342, 2565/4465/5460 | Apirolio | Apirolia | Aroclor | Areclor (t) |
| Arubren | ASK | Bakola 131 | Biclor(c) | Chorextol |
| Chlorextol | C(h)lophen A30 | C(h)lophen A50 | Clophen A60 | Clophen Apirorlio |
| Chlorphen, Chlor-phen (t) | Chloresil | Chlorintol | Chlorinol | Chlorinated Diphenyl |
| Deler, Delor | Dialor (c) | Diaclor | Diachlor | Diaconal |
| Diconal | Disconon (c) | Dykanol | Duconal | DK |
| DP 3,4,5,6.5 | Educarel | EEC-18 | Electrophenyl | Elaol |
| Elemex (t,c) | Elexem | Eucarel | Fenclor 42, 54, 64, 70 | Hexol |
| Hivar (c) | Hydol, Hyvol | Inclor, Inclar | Inerteen 300, 400, 600 | Kan(e)chlor (KC) 200-600 |
| Kanechlor, Kaneclor | Keneclor, 400, 500 | Kennechlor | Leromoli, Leromoll | Magvar |
| MCS 1489 | Montar | Nepolin | Niren | No-Famol |
| No-Flamol, NoFlam-ol | Non-Flammable Liquid | Phenoclar DP6 | Phenoclor DP6 | Plastivar |
| Pydraul | Pyroclar | Pyroclor | Pyrochlor | Pyranol, Pyranal |
| Pysanol | Physalen | Phyralene | Pyralene 1460, 1500, 1501, 3010, 3011 | Pyralene T1, T2, T3 |
| Safe-T-America | Safe-T-Kuhl, Saft-Kuhl | Sant(h)osafe | Santosol | Santvacki |
| Santovac, 1, 2 | Santowax | Santothern FR | Santotherm | Sant(h)othern FR |
| Sant(h)otherm | Siclonyl (c) | Solvol | Sorol | Sovol |
| Therminol, FR | Terpenylchlore | **This list should not be assumed to be exhaustive or all-inclusive. If there is any doubt about whether an item of equipment contains PCBs, assume that it does.* | | |

**For more information:**

Agency for Toxic Substances & Disease Registry (ATSDR) Toxic Substances Portal for PCBs:
https://www.atsdr.cdc.gov/phs/phs.asp?id=139&tid=26

Policy, Fact Sheets, Disposal Requirements and Related information:
https://www.epa.gov/pcbs

U.S Environmental Protection Agency PCB Inspection Manual:
https://www.epa.gov/sites/production/files/2013-09/documents/pcbinspectmanual.pdf ■

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