

CHEMIE ŽIVOTNÍHO PROSTŘEDÍ IV

Vybrané typy environmentálních polutantů

(08/05)

Polychlorované bifenyly (PCBs)

Inventura zařízení

Ivan Holoubek

RECETOX, Masaryk University, Brno, CR

holoubek@recetox.muni.cz; <http://recetox.muni.cz>

PCB Applications

↪ **CLOSED SYSTEMS**

↪ **OPEN SYSTEMS**

Closed Applications

- ↪ **A closed PCB application** is one in which the PCBs are held completely within the equipment.
- ↪ Under ordinary circumstances, **no PCBs would be available for exposure** to the user or the environment.
- ↪ However, **PCB emissions may occur during equipment servicing/repairing and decommissioning, or as a result of damaged equipment.**
- ↪ **The two most significant examples of closed PCB-applications are capacitors and transformers.**

Closed Applications

- ↪ **Electrical transformers**

- ↪ **Electrical capacitors:**
 - *Power factor capacitors in electrical distribution systems*
 - *Lighting ballasts*
 - *Motor start capacitors in refrigerators, heating systems, air conditioners, hair dryers, water well motors, etc.*
 - *Capacitors in electronic equipment including television sets and microwave ovens*

- ↪ **Electrical motors (minor usage in some specialized fluid cooled motors)**

- ↪ **Electric magnets (minor usage in some fluid cooled separating magnets)**

Closed Applications

- ↪ In general, it is often difficult to determine the presence of PCBs in sealed equipment, since breaking open the equipment to ascertain this information will usually be inappropriate.
- ↪ Consequently, the first step should always be to refer to maintenance records, manufacturers' literature, trade associations, and equipment manufacturing companies to find information on dielectric fluids contained in the product.

Closed Applications

- ↪ Equipment should at a minimum be inspected for any indications of leaks, such as oil stains near the equipment, seepage marks on the equipment, or gross physical damage.
- ↪ These are signs that the equipment needs to be analytically tested for PCBs and repaired or possibly replaced.
- ↪ Following are useful details for identifying PCB-contamination in electrical applications.

Transformers

↪ The transformer is a very important component in many different types of electrical circuits, from small-signal electronic circuits to high-voltage power transmission systems.



↪ The physical size and shape of transformers vary greatly, from not much bigger than a pea up to the size of a small house.

↪ The main structure of a transformer consists of one or more electrical coils (or windings) linked together magnetically by a magnetic circuit or core.



Transformers

- ↪ For most large transformers, the entire unit is filled with a dielectric fluid (often an oil possibly containing PCBs) to increase the insulation between and to cool the electric coils.
- ↪ Thus, any damage to the transformer's outer casing may result in PCB-fluid leakage.
- ↪ It is important to note that although mineral oil transformers do not intentionally contain PCBs, they often become contaminated by the use of common filling equipment or maintenance filling with used or recycled oil.

Transformers



- ↪ **Distribution transformers** are commonly found near the top of electric utility poles where they function to lower the voltage on the distribution line for household use.
- ↪ **Synthetic PCB-oils** are commonly used where **fire resistant transformers** are required, as inside buildings and in nuclear power plants.
- ↪ **Transformers** are also found in many **communication circuits** where they function to match a load to a line for improved power transfer and to improve transmission quality.

Transformers



- ↪ Most transformers are within the control of the electricity generating and distributive companies, although some industries privately generate electricity.
- ↪ These industries, such as military installations, steel mills, assembly and manufacturing plants, and railroads, often have transformers on site.
- ↪ *Annex A, Tables A.1, A.2, and A.4 provide additional PCB-containing transformer identification information, including common locations, a list of company names that manufactured PCB-containing transformers, equipment type designations, and PCB mixture trade names.*

Capacitors

- ↪ A capacitor is a device for accumulating and holding a charge of electricity.
- ↪ The main structure of a capacitor consists of electrical conducting surfaces separated by a dielectric material, frequently a dielectric fluid that may or may not contain PCBs.
- ↪ Typically, a capacitor that contains PCBs is a completely sealed metal can with two electrical leads or contacts.
- ↪ The entire can is usually filled with the PCB-containing fluid.

Capacitors

- ↪ Identifying capacitors containing PCB dielectric fluids may be complicated because capacitors are often difficult to locate.
- ↪ They are usually plain boxes that can be remote from switch rooms or found on individual items within a building.
- ↪ *In addition, Annex A, Tables A.1, A.3, and A.4 provide PCB-containing capacitor identification information, including common locations, a list of company and product names, equipment type designations, production dates, and PCB mixture trade names.*

Types of capacitors

- Following are descriptions of three major types/uses of capacitors that may contain PCBs:

Power Factor Correction Capacitors

- **Power factor correction capacitors** are large capacitors that are generally of uniform size (60 cm x 30 cm x 15 cm) and may contain about 1.4 kg of 100% PCB fluid.
- Power factor correction capacitors are usually **located near transformers**, often in racks at power stations.
- **Potential facilities containing capacitors** include factories, offices, schools, hospitals, stores, and military installations.
- **Large capacitors** would likely be found near sizable power supply units within these facilities (e.g., computer equipment rooms, and central heating and cooling systems).

Types of capacitors

Motor Start Capacitors

- **Motor start capacitors** are small capacitors that are used with singlephase motors to provide starting torque.
- The capacitors can be found in **electrical appliances** including hair dryers, washing machines, clothes dryers, down-well water pumps, ventilating fans, and air conditioners.
- These small capacitors generally contain **less than 1.4 kg of dielectric fluid**.

Types of capacitors

Light Ballasts

- Lighting ballasts can be found within fluorescent, mercury, and sodium lighting fixtures, and neon lights.
- Ballasts are composed of a small transformer, a capacitor, and a thermal cut-off switch.
- The capacitor is the only component that may contain PCBs, typically approximately 0.1 kg of PCB fluid.
- In fluorescent lights, the ballast is located under the metal cover plate that is behind the lighting tubes (lamps).
- Ballasts manufactured in the US after 1978 are labeled “No PCBs,” and therefore any unlabeled ballast from a US source should be assumed to contain PCBs (US EPA 1993).

Annex A, Tables A.1 and A.4 provide additional PCB identification information, including common locations, and PCB mixture trade names.

Partially closed applications

- ↪ **Partially closed PCB applications are those in which the PCB oil is not directly exposed to the environment, but may become so periodically during typical use.**
- ↪ **These types of uses may also lead to PCB emissions, through air or water discharge.**
- ↪ **Examples of partially closed systems include heat transfer and hydraulic systems, and vacuum pumps.**

Partially closed applications

Application	Typical Location(s)
Heat transfer fluids	Inorganic chemical, organic chemical, plastics and synthetics, and petroleum refining industries
Hydraulic fluids	Mining equipment; aluminum, copper, steel, and iron forming industries
Vacuum Pumps	Electronic components manufacture; laboratory, instrument and research applications; and waste water discharge sites
Switches ^a	Electric utilities
Voltage Regulators ^a	Electric utilities
Liquid Filled Electrical Cables ^a	Electric utilities, and private generation facilities (e.g. Military installations)
Liquid Filled Circuit Breakers ^a	Electric utilities

^a These applications were not generally designed to contain PCB materials but may have become contaminated through regular maintenance and servicing.

Open applications

- ↪ **Open systems are applications in which PCBs are in direct contact with their surroundings and thereby may be easily transferred to the environment.**
- ↪ **Direct PCB contact with the environment is of greater concern for open uses than it is for closed applications.**
- ↪ **Plasticizers are the largest group of open applications and are used in PVC (polyvinyl chloride), neoprene, and other chlorinated rubbers.**
- ↪ **In addition, PCBs have been used in a number of other open uses including in paints as flame-retardants, adhesives as plasticizers, and in surface coatings as flame-retardants.**

Open applications

↪ Lubricants

- Immersion oils for microscopes (mounting media)
- Brake linings
- Cutting oils
- Lubricating oils
 - * Natural gas air compressors

↪ Casting Waxes

- Pattern waxes for investment castings

Open applications

↪ Surface Coatings

➤ Paints

- * Paint on the undersides of ships

➤ Surface treatment for textiles

➤ Carbonless copy paper (pressure sensitive)

➤ Flame retardants

- * On ceiling tiles

- * On furniture and walls

➤ Dust Control

- * Dust binders

- * Asphalt

- * Natural gas pipelines



↪ Adhesives

➤ Special adhesives

➤ Adhesives for waterproof wall coatings

Open applications

- ↪ **Plasticizers**
- **Gasket sealers**
- **Filling material in joints of concrete**
- **PVC (polyvinyl chloride plastics)**
- **Rubber seals**
 - * Around vents
 - * Around doors and windows



Open applications

↪ Inks

➤ Dyes

➤ Printing inks

↪ Other Uses

➤ Insulating materials

➤ Pesticides ^a

^a Scrap transformer fluid has been used as an ingredient in pesticide formulas

PCB-containing wastes

Although the manufacture, processing, distribution, and use of PCBs are widely prohibited, there still exist a host of different activities that generate PCB wastes, including:

- ↪ exemptions given to certain uses of PCBs;
- ↪ the incidental production of PCBs;
- ↪ recycling operations;
- ↪ and quantities held within equipment still in service.

Annex A, Tables A.1 and A.5 provide additional identification information for PCB-containing wastes, including common locations and sources.

PCB-containing wastes

Specific examples of activities that generate PCB wastes include:

- ↪ PCBs in used oil
- ↪ Navigational dredging of PCB-contaminated waters and sediments
- ↪ Repair and decommissioning of equipment
- ↪ Building demolition
- ↪ Volatilization and leaching from landfills
- ↪ Recycling operations
- ↪ Incinerators
- ↪ Inadvertent production by organic chemical manufacturing and use industries

PCB in used oil

- ↪ Because PCBs were widely used in equipment that is still in service today, waste oil collected from this equipment frequently contains detectable PCB concentrations.
- ↪ PCB-contaminated used oil comes principally from industrial and automotive sources and electrical equipment.
- ↪ Industrial sources are typically plants and factories where used oil is used as a fluid in hydraulic and heat transfer systems.
- ↪ Used PCB transformer oil has often been mixed with used mineral oil in oil recycling operations, such that low concentrations of PCBs are often found in recycled oil used in trucks and automobiles.

PCB in used oil

- ↪ **Automotive sources are generally gasoline stations and commercial vehicle fleets that collect oil from engine crankcases, transmissions, radiators and other vehicle-related systems.**
- ↪ **In addition, the condensate in natural gas pipelines can become contaminated with PCBs by contacting PCB containing oils used in the compressors of such pipelines.**
- ↪ **Users of waste oil should use the tests to determine PCB presence and concentration.**

Navigation Dredging of PCB-Contaminated Waters and Sediments

- ↪ Over the years, large quantities of PCBs have been discharged into aquatic environments including rivers, lakes, and estuarine systems.
- ↪ PCBs tend to adsorb strongly to sediments.
- ↪ Dredging of the bottom to allow ship navigation can therefore generate waste sediments contaminated with PCB levels above 50 ppm.
- ↪ PCBs were used in hydraulic fluids in mining equipment and this use was one of the major sources of PCBs that have settled in river water and river sediments.

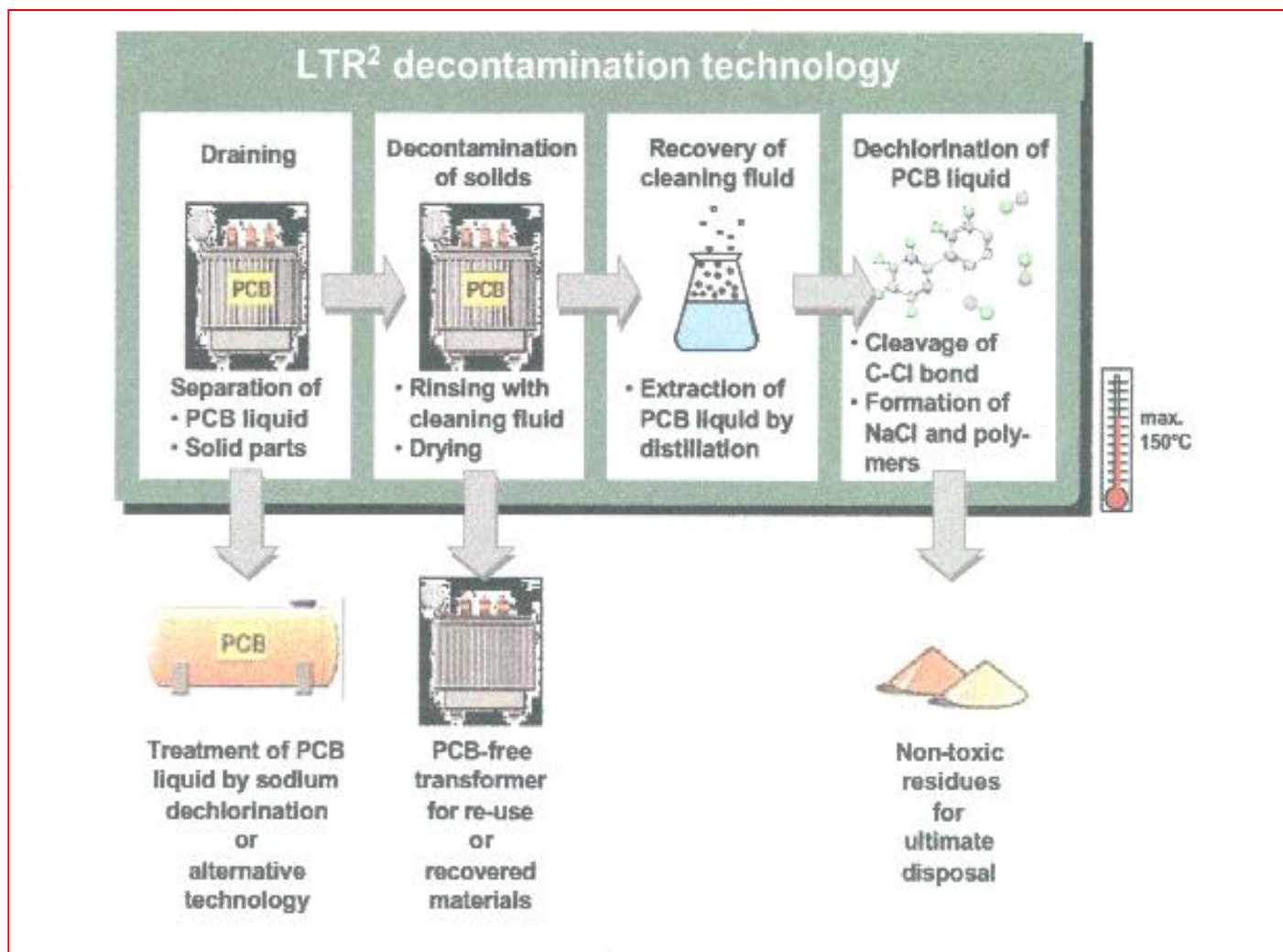
Repair and decommissioning of equipments

- ↪ The repair and maintenance of PCB-containing equipment is a source of toxic waste.
- ↪ For example, in the event of a breakdown, transformers are repaired either by the manufacturer or, more often, in repair shops which creates PCB containing wastes at these locations.
- ↪ Additional significant sources of PCBs may include waste materials generated by cleanup of dielectric fluid leaks at industrial facilities and the explosion or overheating of transformers and capacitors.

Repair and decommissioning of equipments

- ↪ Furthermore, the decommissioning of PCB-containing equipment may introduce (formerly contained) PCBs into the environment, often in the form of fluff (waste including upholstery, padding and insulation materials derived from the shredding of cars and electrical appliances).
- ↪ Given that transformers and electrical capacitors tend to have relatively long service lives (~ 40 years), the PCBs used in these applications will continue to present a disposal problem well into the next century.

LTR² (Low Temperature Rinsing and Re-use) system of ABB



Building demolition

- ↪ In general, large amounts of waste are produced through the demolition of buildings.
- ↪ Of this waste, PCBs are to be found in filling material for joints of concrete structures, flame-retardant coatings on ceiling boards (or tiles), fluorescent light ballasts, coatings on furnishings, surface treatments for textiles, adhesives for waterproof wall coatings, paints, insulating materials, sealant putties, and large and small capacitors (found in appliances and electrical devices).

Volatilization and leaching from landfills

- ↪ Of the PCBs that have already been disposed, most have likely been deposited in landfills, including municipal, industrial, and sewage sludge landfills.
- ↪ However, PCBs may be released from these landfills by volatilization into the atmosphere and leaching into groundwater.
- ↪ It is likely that much of the PCBs distributed in the waste was originally enclosed in containers, such as capacitors, or was in plasticized resins and will not be released to the environment until the containing medium decays or is damaged.
- ↪ Thus, the diffusion of PCBs from landfills is likely to be slow.

Recycling operations

- ↪ Through various recycling operations, PCBs have found their way back into the commercial stream.
- ↪ For example, waste paper supplies (carbonless copy paper) may have been recycled into paper and board used as food packaging materials.
- ↪ Another major pathway of PCB environmental exposure is through scrap and waste oil recycling.
- ↪ Additionally, recycled PCB-containing mixtures have been detected in formulations for pesticides and soft soap.

Incinerators

- ↪ Emissions of PCBs may occur during the incineration of industrial and municipal waste (e.g., refuse and sewage sludge incinerators).
- ↪ Most municipal incinerators are not effective in destroying PCBs.
- ↪ It is recommended that destruction of PCB-contaminated waste should be carefully controlled, especially with regard to the burning temperature (above 1 100 °C), residence time, and turbulence.

Inadvertent production by organic chemical manufacturing and use industry

- ↪ There are a number of industrial processes in the organic pigment, pesticide, chemical, and aluminum refining industries that inadvertently produce PCB-laden materials.
- ↪ PCBs can be produced when chlorine, hydrocarbon, and elevated temperatures (or catalysts) are present together.
- ↪ Approximately 90 percent of this production is expected to contain less than 50 ppm of PCBs, and approximately 5 – 10 percent may contain between 50 and 500 ppm of PCBs.