PCB Management Guidance

Maintenance, Handling, Transport and Interim Storage of Liquids Containing PCB and Equipment Contaminated with PCB

PCB Elimination Network (PEN)

This document was produced by the Thematic Group on Inventories of the PCB Elimination Network (PEN). The electronic version is available for download on the webpage of the UNEP Chemicals and Waste Branch at http://www.unep.org/chemicalsandwaste/POPs/ChemicalsManagementandReduction/PhasingoutPCBcopy/PCBEliminationNetworkCopy/tabid/1061160/Default.aspx and from the PEN's Webpage at: http://chm.pops.int/Implementation/PCBs/DocumentsPublications/tabid/665/Default.aspx

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Abbreviations

COP	Conference of the Parties
GC-MS	Gas chromatography-mass spectrometry
IARC	International Agency for Research on Cancer
IMDG	International Maritime Dangerous Goods
PBB	Polybrominated biphenyls
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
PCTs	Polychlorinated terphenyls
PEN	PCB Elimination Network
POPs	Persistent Organic Pollutants
TMN	Transboundary Movement Notification

1. Introduction

Polychlorinated biphenyls (PCB) are aromatic hydrocarbon compounds, consisting of two benzene rings linked by a carbon-carbon bond. The hydrogen atoms can be substituted by up to ten chlorine atoms. PCB exist as viscous liquids or resins and may be colourless or yellowish with a strong, characteristic smell. One of the most important characteristics of PCB is that they have excellent dielectric properties, are resistant to chemical and thermal degradation (they decompose at high temperatures above 1000 °C), are not affected by light and are not flammable.

Due to their physico-chemical properties, PCB were manufactured worldwide for use in a wide range of applications, most importantly as insulating fluids in transformers. PCB were also used in other types of closed and semi-closed applications, such as capacitors, as well as in so-called 'open applications, such as paints, sealants and carbon paper.

However, PCB can cause serious health effects in humans and animals, including reproductive impairment and immune system dysfunctions. The International Agency for Research on Cancer (IARC) classified PCB as Group 1 "carcinogenic to humans". PCB Among POPs, the second highest concentrations in human milk is for PCB. In some cases, observed levels for indicator PCB were several orders of magnitude higher than the WHO safety level[1]. Once in the environment, PCB enter the food chain: More than 90% of human exposure to PCB is through food.

PCB are therefore regulated under the Stockholm Convention on Persistent Organic Pollutants (POPs) [2]. The Convention bans the production and new uses of PCB and requires Parties to eliminate the use of PCB in equipment by 2025 and to ensure the environmentally sound waste management of liquids containing PCB and equipment contaminated with PCB by 2028.

However, countries still face many challenges in ensuring the environmentally sound management of PCB. The purpose of this PCB Management Guidance is to support stakeholders engaged in the maintenance, handling, transport and interim storage of liquids containing PCB and equipment contaminated with PCB, taking into account practical experience and applicable international obligations.

Based on collected experiences and lessons learned from experts, countries and companies, existing guidelines on inventories and handling of PCB, and relevant regulations taking into account regional variations, the guidance lists and explains relevant technical guidelines, outlines important procedures and provides practical recommendations for implementation. The guidance also features a bibliography and links sections, where the reader can find references to documents of international organizations and other stakeholders that were consulted to prepare the present guidance document.

The guidance is intended for use by government agencies, institutions, companies, and individuals involved in the processes of maintenance, handling, transport and interim storage of liquids containing PCB and equipment contaminated with PCB, including related steps and procedures. It primarily targets developing countries and countries with economies in transition in need of assistance to ensure the environmentally sound management to developing countries or countries in economic transitions that have started the management process or that are still working on it.

[1] See for instance the monitoring reports under the Stockholm Convention at : http://chm.pops.int/Implementation/GlobalMonitoringPlan/MonitoringReports/tabid/525/Default.aspx

[2] Stockholm Convention on Persistent Organic Pollutants, full text available at: http://www.pops.int

2. International Legal Framework

PCB are regulated under three international conventions, namely the Stockholm Convention, the Basel Convention and the Rotterdam Convention.

2.1. STOCKHOLM CONVENTION

The objective of the Stockholm Convention on POPs, which entered into force in 2004 is to protect human health and the environment from persistent organic pollutants. The convention includes the following aspects:

a) The implementation of measures to reduce or eliminate the intentional production and use of POPs.

b) The implementation of measures to reduce or eliminate emissions from unintentional production of POPs.

c) The implementation of measures to reduce or eliminate stocks and wastes consisting of or containing POPs.

PCB were one of the initial twelve POPs. They are listed in Annex A on Elimination, which stipulates that the production of PCB is prohibited. It also stipulates that PCB may only be used in articles in accordance with the provisions of Part II of the Annex, i.e.:

Each Party shall:

(a) With regard to the elimination of the use of polychlorinated biphenyls in equipment (e.g. transformers, capacitors or other receptacles containing liquid stocks) by 2025, subject to review by the Conference of the Parties, take action in accordance with the following priorities:

(i) per cent polychlorinated biphenyls and volumes greater than 5 litres;

(ii) Make determined efforts to identify, label and remove from use equipment containing greater than 0.05 per cent polychlorinated biphenyls and volumes greater than 5 litres;

(iii) Endeavour to identify and remove from use equipment containing greater than 0.005 percent polychlorinated biphenyls and volumes greater than 0.05 litres;

(b) Consistent with the priorities in subparagraph (a), promote the following measures to reduce exposures and risk to control the use of polychlorinated biphenyls:

(i) Use only in intact and non-leaking equipment and only in areas where the risk from environmental release can be minimised and quickly remedied;

(ii) Not use in equipment in areas associated with the production or processing of food or feed;

(iii) When used in populated areas, including schools and hospitals, all reasonable measures to protect from electrical failure which could result in a fi re, and regular inspection of equipment for leaks;

(c) Notwithstanding paragraph 2 of Article 3, ensure that equipment containing polychlorinated biphenyls, as described in subparagraph (a), shall not be exported or imported except for the purpose of environmentally sound waste management;

(d) Except for maintenance and servicing operations, not allow recovery for the purpose of reuse in other equipment of liquids with polychlorinated biphenyls content above 0.005 per cent;

(e) Make determined efforts designed to lead to environmentally sound waste management of liquids containing polychlorinated biphenyls and equipment contaminated with polychlorinated biphenyls having a polychlorinated biphenyls content above 0.005 per cent, in accordance with paragraph 1 of Article 6, as soon as possible but no later than 2028, subject to review by the Conference of the Parties;

(f) In lieu of note (ii) in Part I of this Annex, endeavor to identify other articles containing more than 0.005 per cent polychlorinated biphenyls (e.g. cable-sheaths, cured caulk and painted objects) and manage them in accordance with paragraph 1 of Article 6;

(g) Provide a report every fi ve years on progress in eliminating polychlorinated biphenyls and submit it to the Conference of the Parties pursuant to Article 15;

(h) The reports described in subparagraph (g) shall, as appropriate, be considered by the Conference of the Parties in its reviews relating to polychlorinated biphenyls. The Conference of the Parties shall review progress towards elimination of polychlorinated biphenyls at five year intervals or other period, as appropriate, taking into account such reports.

2.2. BASEL CONVENTION

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal[3], which entered into force in 1992, aims to protect human health and the environment from the harmful effects of hazardous wastes.

The requirements of the Convention are based on its main objectives:

a) Reduction of hazardous waste generation and promotion of environmentally sound management of hazardous wastes wherever final disposal takes place.

b) The control or restriction of transboundary movements of hazardous wastes, except where the movement is necessary to achieve environmentally sound management of the wastes.

c) A regulatory system applicable to transboundary movements that are permitted in particular cases.

Annex I of the Convention contains a list of categories of wastes or waste streams that need to be controlled. Within this list of waste streams is the category Y10, which concerns: "Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)".

All wastes, equipment, oils, substances or materials contaminated with PCB at a concentration greater than 50 mg/kg are considered toxic[4]. Exports of equipment and oils contaminated with PCB above this threshold must be in compliance with the regulations under the Basel Convention. Among others, this means that PCB wastes can only be exported with the written prior informed consent of the importing state and for environmentally sound management. All equipment containing coolant liquids at concentrations below 50 mg/kg PCB are internationally recognized as being PCB-free and having no special requirements.

[3] http://www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx

[4] Category A3180 of List A3, Annex VIII

Under the Basel Convention, 'technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with PCBs, PCTs or PBBs, including HBB' are available to guide Parties.

2.3. ROTTERDAM CONVENTION

The 'Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade'[5], which entered into force in 2004, aims to:

a) to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm;

b) to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process on their import and export and by disseminating these decisions to Parties.

The Convention covers pesticides and industrial chemicals that have been banned or severely restricted for health or environmental reasons. PCB are included in Annex III, which lists chemicals subject to the prior informed consent procedure.

[5] http://www.pic.int/TheConvention/Overview/TextoftheConvention/tabid/1048/language/en-US/Default.aspx

3. Identification of Potential User Sectors

Detailed guidance on the identification of relevant sectors is available in the 'PCB Inventory Guidance'[6].

Even though PCB were used extensively between 1920 and 1980 and despite the fact that nowadays their production and sale are prohibited, PCB still continue to be used in equipment in operation with a limited life-time and are therefore still considered environmental liabilities. PCB can be found in closed applications, partially closed applications and open applications. Below is a list of concerned equipment, materials or uses in the different sectors to facilitate easy identification.

ELECTRICITY GENERATION, TRANSMISSION AND DISTRIBUTION

a) Transformers and capacitors
   - Voltage regulators (high voltage power lines)
   - Starting aid (single-phase motors)
   - Power factor correction: rectifiers, induction motors, ovens
   - Electrical consumer goods: refrigerators, televisions, washing machines
   - Pumps for wells
   - Lamp Ballasts: Fluorescent high intensity discharge
   - Electrical cables

b) Switch gear
   - Capacitors and transformers

c) Manufacturing of machinery
   - Capacitors, transformers and related switch gear

d) Mineral oils contaminated with PCB
   - Cross contamination resulting from oil changes in transformers.

TRANSPORTATION (RAILWAY INFRASTRUCTURE, PORTS, AIRPORTS)

a) Transformers
b) Large capacitors
c) Voltage regulators
d) Circuit breakers

MILITARY (HIGH VOLTAGE EQUIPMENT SUCH AS RADARS)

a) Transformers
b) Large and small capacitors
c) Voltage regulators
d) Circuit breakers
e) Lamp ballasts
f) Hydraulic fluids

MINING (OPEN PIT AND UNDERGROUND)

a) Transformers
b) Large capacitors
c) Units of power factor correction
d) Hydraulic fluids
e) Voltage regulators

[6] http://www.unep.org/chemicalsandwaste/POPs/tabid/1061034/Default.aspx

f) Circuit breakers

INDUSTRIAL PROCESSES AND CASTING OF METALS (ALUMINUM, COPPER, IRON AND STEEL; CEMENT, PLASTICS AND SYNTHETIC PRODUCTION; AND PETROLEUM REFINING)

a) Transformers
b) Large and small capacitors
c) Units of power factor correction
d) Heat transfer fluids
e) Hydraulic fluids
f) Voltage regulators
g) Fluid-filled cables
h) Circuits breakers
i) Lamp ballasts

AGRICULTURE

a) Large and small capacitors
b) Units of power factor correction
c) Submersible pumps

LARGE BUILDINGS, SCHOOLS, UNIVERSITY, ADMINISTRATION, ETC.

a) small capacitors
b) Circuits breakers
c) Lamp ballasts

LOCAL OR MUNICIPAL AUTHORITIES (WATER TREATMENT, DISTRIBUTION NETWORKS, WATER TREATMENT PLANTS AND PUBLIC LIGHTING)

a) Vacuum and submersible pumps
b) Small capacitors
c) Units of power factor correction

RESEARCH LABORATORIES

a) Vacuum pumps
b) Lamp ballasts
c) Small capacitors
d) Circuits breakers

SOLIDS CONTAMINATED WITH PCB

a) Cleaning material
b) Personal protective equipment
c) Maintenance machinery
d) Soil, sand, asphalt, sediment
e) Used test kits
f) Anti-corrosion coatings

OPEN SYSTEMS

a) Ingredient of adhesives
b) Ingredient in paints and other coatings
c) Ingredient in inks
d) Ingredient in lubricants, sealants and caulking material

e) Plasticizer in polyvinyl chloride, neoprene and other synthetic resins
f) Pesticide diluents
g) Flame retardant in fabrics, carpets, polyurethane foam
h) Lubricants for microscopes, brake linings, knifes, etc.
i) Waxes
j) Asphalt
k) Gas pipeline capacitors
l) Plasticizers

4. Responsibilities of Owners

The environmentally sound management of liquids containing PCB and equipment contaminated with PCB falls primarily under the responsibility of the owners of these items. This responsibility covers undertaking of the inventory until final disposal in an environmentally sound manner.

Once an equipment with PCB above the relevant threshold reaches the end of its lifespan, it is necessary to initiate the disposal process. This involved draining the oil from the equipment and placing it in UN-approved metal containers. The container has to be in good condition, without any damage and it cannot be leaking. If necessary, the liquids need to be appropriately re-packaged. Once the equipment is drained, it must either be stored in an environmentally sound manner pending final disposal or be sent to a facility approved for the treatment of liquids containing and equipment contaminated with PCB. Several possible solutions for decontamination and disposal of PCB oils are discussed in further detail in this guidance.

If applicable, the owners have a responsibility to submit documents required for the notification of a transboundary movement of hazardous wastes to the competent authority of their country.

5. Information management

5.1. Creating a Database and Tracking System for Equipment and Materials Contaminated with PCB

The result of the initial inventory of liquids containing and equipment contaminated with PCB should be compiled in a national database. This database is the starting point for continuing the identification of liquids and equipment and for initiating the removal of identified stocks. As such, it should be regularly updated and maintained.

The inventory information can be inserted into many different types of databases, but the simplest way is to use an Excel spreadsheet. The sheet should contain information on the characteristics of the liquids and equipment, including the type of equipment, date of manufacture, solid and liquid weight, and PCB content. It is also recommended to insert information on the owners of the liquids and equipment.

A possible structure of an Excel sheet is shown below:

Table 1: Excel structure for the information on the liquids and/or equipment, including the owner

Description	**Value/Standard table**
Type of equipment	Transformer, capacitor, lamp ballasts, circuit breaker, etc.
GPS coordinates	
Manufacturer	
Serial number	
Current range (KVA)	
Year of manufacture	
Weight (kg) oil	
Weight (kg) housing	
Appearance	
Name of oil	
Range of liquid PCB content (mg/kg)	
Exact PCB content (mg/kg)	
Analysis performed (yes or no)	
Method of analysis	
Date of analysis	
Information source (inventory/maintenance)	
Operational status (in operation/out of use)	
Filled (yes or no)	
Date of filling	
Oil filled	
Date when became waste (taken out of use)	
Next maintenance service date	
Equipment identification	
Name of the PCB owner	

Address	
Telephone number	
Fax number	
Name of the contact person	
E-mail	
Type of business	

This database could be kept only for liquids equipment and oils that (potentially) contain/are contaminated with PCB, but for greater control and to avoid possible cross-contamination it is recommended to track this information for all transformers in use and out of use.

5.2. MAINTAINING THE DATABASE AND MONITORING EQUIPMENT

A database is a tool that allows keeping track of the location and use of the contaminated liquids and equipment by using labels and geo-referencing or, as a more basic procedure, by keeping track of the physical location of the equipment.

Once the database is established on the basis of the initial inventory, it is very important to regularly update the information. Thus, as liquids and equipment are taken out of use and placed in storage or sent for treatment and disposal, these should be added to the database, unless they have already been included.

In most cases, the database is updated with information as equipment enters the maintenance process and/or reaches the end of its lifespan. As the equipment is taken out of use, tests should be conducted to ascertain whether it is contaminated with PCB. The information on the equipment should then be included in the existing database. This process will need to be undertaken for a number of years until a full inventory of stocks of PCB liquids and equipment has been completed.

Liquids and equipment that are found to contain/be contaminated with PCB should be added to the database. Liquids and equipment that have successfully been decontaminated or destroyed can be removed from the inventory (it may be advisable to indicate this accordingly). If the equipment is shipped abroad for treatment or destruction, it is necessary to include in the database a reference to the respective documentation under the Basel Convention, the date of shipment, the country of destination and the receiving facility.

6. Management of PCB Liquids and Equipment

PCB liquids and equipment, whether in use or out of use, need to be monitored throughout their life-cycle. Likewise, the environmentally sound interim storage of liquids and equipment pending decontamination or final disposal, needs to be secure[7].

6.1. Management of Transformers Prior to Testing

If there is reason to suspect that a transformer is potentially contaminated by PCB, all appropriate precautionary measures for handling it must be considered. The following steps should be followed:

1) Read the plate of the equipment carefully trying to identify all information including its brand name, serial number, voltage ratio, wattage, manufacturing date, origin and type of insulating fluid. It is very important to note the AC power (KVA or MVA), because it will be used to estimate the weight of the equipment and the oil, which will then be used to estimate costs for disposal.

2) If the equipment has a label, which indicates a name of insulating fluid different than mineral oil or silicone, look immediately at the list of brands and types of PCB that are attached to this guidance in the Annex. There you should find the fluid that you are looking for. If this is the case, your equipment is certain to contain pure PCB or be contaminated with PCB.

3) If the equipment has no label or if this does not indicate the type of dielectric fluid used, the strong and irritating characteristic odour of PCB and its density approximating 1.5 (compared to oils whose density is between 0.85 and 0.9) can give a first indication of the presence of PCB[8].

4) In both of the situations described above, the equipment should be isolated immediately and labelled.

5) Check the transformer cover and see if the seal has been opened and if a seal different than the original is used. If that is the case, the oil information on the label is not valid and it should be investigated if in the past the equipment underwent some kind of maintenance, during which the oil was extracted and re-filled with another oil. If that was the case, investigate where the extracted oil was put.

6) In parallel to this research, carry out a PCB test of the equipment using a Chlor-N-OIL kit. If the result if positive, it means that the oil contains chlorine. This is not yet a confirmation of PCB content. Indicate this on the label and put the equipment in a covered place, protected from water and sun and inform the staff in charge to not manipulate the equipment in any way.

7) Send an oil sample to a chemical laboratory where a gas chromatography analysis can be carried out to determine whether the oil contains PCB and, if so, to quantify the concentration and to find out whether you are dealing with pure PCB or contaminated oil. In the latter case, it means that the original fluid was extracted and the equipment re-filled with another fluid. In this case you should investigate where the original oil was put in order to

[7] "Training Manual for the preparation of a national Environmentally Sound Management plan for PCBs and PCB-contaminated equipment in the framework of the implementation of the Basel Convention", UNEP/Secretariat of the Basel Convention, 2003, ISBN: 92-1-158674-7.

[8] "PCB Transformers and Capacitors - From Management to Reclassification and Disposal", UNEP, 2002.

safeguard it.

8) In both cases, if a PCB content of over 50 mg/kg is confirmed, the equipment containing the liquid should be properly labelled and transferred securely to the temporary storage facility. Alongside, all the information on this equipment must be incorporated into the database.

9) In the event that the result of the gas chromatography analysis shows a negative result of the presence of PCB, the equipment can be handled as a normal piece of equipment.

10) If the result shows a value below 50 mg/kg, although the equipment will be considered non-toxic, it should be kept under control for future maintenance activities. Due to the fact that PCB are accumulative and not biodegradable, even small concentrations may accumulate in the future to higher concentrations and become a problem.

6.2. PRELIMINARY SAMPLING AND TESTING

The methods commonly used methods in the field and 'in situ' (i.e. on-site) to detect PCB in dielectric oil samples are the the Chlor-N-Oil test kits and the L2000DX Analyser. These can be used to detect chlorine content in the sample. It is important to note that a positive result does not necessarily confirm the presence of PCB. and therefore the presence of PCB. In both cases, either for sampling or for implementation of the method, it is necessary to follow the manufacturer's specific instructions.

The following personal protective equipment should be used:

- Nitrile gloves
- Laboratory safety glasses
- Apron or lab coat

After performing the analysis, the waste from the kit must be properly disposed of, since the wastes contain chemicals.

6.3. FALSE POSITIVE RESULTS

When performing a gas chromatography analysis on a sample that was tested positive with the test kit, the result might be that there is no presence of PCB or that the concentration is less than 50 mg/kg. Thus, the test kits may give 'false positive' results. This may be due to the following reasons:

1) The test kits only detect chlorine content in the sample, which must not necessarily be due to the presence of PCB. A laboratory analysis is therefore always necessary to confirm the presence of PCB and the concentration of PCB in the sample. Where this is not possible, the equipment should be labelled as suspected to contain PCB.

2) False positive results with the kit are due to the presence of water in the oil sample. One way of overcoming this limitation of the test kit is to extract the water from the oil sample through a mechanical process of centrifugation. During this process the sample is centrifuged at a speed and time set to ensure the removal of the water. Afterwards, the test kit is reapplied: if the false positive result was due to the presence of water, the result of the test should now be negative. This method of removing water from oil is recommended because being a mechanical method, the matrix of the sample is not changed, as it would be if you added a chemical that would react with the oil or PCB molecules.

6.4. LABORATORY ANALYSIS TO CONFIRM PRELIMINARY RESULTS

One of the most recommended and applied analyses to confirm the presence of PCB is by gas chromatography using electron capture detector. There are other more complex types of analyses such as gas chromatography-mass spectrometry (GC-MS).

The chromatographic analysis is a physical method of separation to characterize complex mixtures, which is applied in all branches of science and physics. It is a set of techniques based on the principle of selective retention, which aims to separate the different components of a mixture, allowing to identify and determine the amounts of these components.

During a gas chromatography the sample is passed through a mobile phase consisting of a gaseous fluid which carries the sample through a solid stationary phase. The components of the mixture interact in different ways with the stationary phase. Thus, the components pass through the stationary phase at different speed and get separated. After the components have passed through the stationary phase and have been separated, they pass through a detector which generates a signal depending on the concentration and type of compound.

This detector is very selective, and is sensitive to the presence of molecules with electronegative groups such as halogens, peroxides, quinones and nitro groups, groups containing halogen atoms (chlorine, bromine, and iodine), oxygen and nitrogen. It is applied to detect molecules containing halogens, especially chlorine, for example in some pesticides or polychlorinated biphenyls.

6.5. ISOLATION OF EQUIPMENT

Once you have confirmed the presence of PCB in out of service equipment at a concentration over 50 mg/kg, it is essential to isolate it from PCB free equipment, label it and safeguard it in a shelter to avoid cross-contamination and human exposure.

If the equipment does not leak and will be stored only temporarily, the oil can be left in the equipment without draining it, placing a drip tray below it as a precaution. However, if the equipment has leaks or the storage time is unknown, the oil must be drained into containers in good condition, fully sealed and approved by the International Maritime Dangerous Goods (IMDG) code for this purpose, and labelled in accordance to international regulations.

6.6. HANDLING OF IN-SERVICE EQUIPMENT

If it has been confirmed that in-service equipment, which cannot be taken out of use, contains more than 50 mg/kg PCB and, it may continue in service provided that no leak occurs and that the following security measures are taken:

- Label the equipment indicating its status.
- Inform the personnel about the danger, the necessary precautions and measures to take in case of accidents.
- Isolate the equipment and apply a tape indicating its hazard.
- Put a drip tray or absorbent material barrier below the equipment, in case of leakage.
- If leaks occur, the equipment needs to be taken out of use immediately, the oil removed and the equipment stored securely.
- Check the impermeability of the equipment periodically.

The concerned pieces of equipment should be inspected and monitored thoroughly.

The main objectives of proper handling of equipment contaminated with PCB in service are:

- to prevent leaks and spills in the environment;
- to protect the equipment from electrical failures that may cause accidents and fires;
- to protect the equipment from external fire hazards to which they may be exposed; and
- to maximize safety precautions for personnel in charge and when servicing the equipment.

6.7. POLLUTION PREVENTION AND REDUCTION

The most important aspect of preventing and minimizing cross-contamination of PCB in equipment, soil, water and air is to ensure the environmentally sound storage of contaminated equipments, whether still in service or out of service[9].

The tools and other equipment used for handling PCB must be isolated and safeguarded, but can still be used for future tasks of handling PCB. More detail is provided below.

6.8. WASTE DISPOSAL

All solid and liquid wastes contaminated with PCB need to be shipped for environmentally sound treatment. Such waste may include:

- Kits used to detect chlorine content or expired test kits: These are not only potentially contaminated with PCB, but may also contain other toxic chemicals such as mercury. Used and expired test kits should be eliminated using an appropriate treatment methodology.
- Desiccant (sawdust, fabric), tools, gloves, clothes, rags, etc. These must be properly placed in plastic or metal containers, sealed and marked with the appropriate label for waste PCB.
- Transformers containing or having contained mineral oil with PCB
- Parts of equipment containing or having contained PCB
- Containers that are no longer usable that used to contained PCB;
- Washing liquids containing more than 0.5 ug/L of PCB
- Soil and debris

6.9. TRAINING

The basis for protecting the personnel working with (potentially) contaminated equipment and containers is to keep them well informed and trained about:

- the significance of PCB, including their health effects and their potential impacts on the environment;
- relevant domestic and international regulations and guidelines; and
- environmentally sound handling and related precautionary and safety measures, including labelling, transport and storage.

[9] "PCB Transformers and Capacitors - From Management to Reclassification and Disposal", UNEP, 2002.

Targeted face-to-face trainings can be complemented (but not replaced) by lectures, workshops, exhibitions and dissemination of information through posters.

6.10. Security and Control Measures at the Work Place

The following basic security measures should be followed in areas with PCB liquids and equipment:

- adequate ventilation;
- concrete floors; and
- appropriate fire extinguishing systems.

Personal protective equipment (PPE)

For any work involving the handling of PCB liquids and equipment (including suspected liquids and equipment), the staff must at all times have proper protective materials and equipment:

- A protective apparel that resist penetration by most organic chemicals and toxic dusts, made of chemicals resistant materials such as TYVEK
- Chemical splash goggles
- Chemicals resistant gloves like nitrile disposable gloves, these are made of a copolymer that provide protection from chlorinated substances
- Footwear that protects against chemicals
- A protective mask of organic gases, vapours, solid and toxic particles (the recommended filter is A2P2)

The exact type and amount of security accessories needed depend on the activity that will be carried out. If equipment or containers need to be handled for taking only a sample or doing an inspection, it is not necessary to wear the kimono and the mask. If the activity involves the re-filling of oil, it is absolutely necessary to use all the accessories listed above.

6.11. Disclosure of Information to the Public

Although PCB can represent a danger to the population if not handled properly, spreading wrong information or misinforming people can create unnecessary panic and can be counterproductive. The population should be duly informed of the issue to avoid both unnecessary panic and alarm and a dangerous and risky carelessness.

Communities should be informed about PCB and their potential health effects, environmental impacts, actual exposure risks, what to do and who to call in case of encountering a suspicion on the presence of PCB.

6.12. Packaging

The UN has stipulated requirements for containers suitable for the transport of hazardous substances. These requirements specify certain characteristics that the packing materials have to comply with. The coding used on the packaging is referred to as the UN certified packing system code.

In the particular case of the storage and transport of materials containing or contaminated with PCB, the containers must meet the UN specifications of and be identified with the packing code on the outside for this substance. The containers should be packed up to a maximum of 90% of its total capacity.

An example of how to interpret the UN certified packaging system code is as follows: 1H2 / Y1.8 / 100 / 06 / F / OA30900, where:

1: Type of container, which can be drums, barrels, bags, etc

H: Material of the container, which can be steel, aluminium, wood, fibre, plastic, etc.

2: Category, open top container (used for solids) or closed with only a small opening for filling or draining (used for liquids).

Y: Packing group for which the container was tested:

X: for packing groups I, II, III

Y: For packing group II and III

Z: for packing group III

Group I: High level of risk

Group II: Medium level of risk

Group III: Low level of risk

1.8: Specific density or gravity of the packed material

100: Hydraulic pressure in kPa

06: Year

F: Country where the container was manufactured

OA30900: Manufacturer Code

It is recommended that if the container has been recycled and there are no certified codes, it should not be used as it does not comply with the terms of the original brand. It is also recommended to check the year of manufacture of the container, to verify that it is not over 5 years old when used.

6.13. LABELLING

The purpose of labelling equipment and containers with PCB is to alert persons involved in the handling, storage and transport of these substances on the risks and precautions that need to be taken to ensure their safety.

The UN has established codes to label equipment and containers. The information on the containers should include those provided in the table below. Liquid PCB wastes must be packed in sealed containers and solid waste in wide-mouth containers.

Table 2: UN Labelling Format

UN code		**Safety data sheet**	
Group Nº	90201	Chlorine content	Between 42 and 62%
UN Code	2315	Melting point	-19ºC
IMO[10] class	9	Evaporation temperature	325ºC

[10] IMO= International Maritime Organization

Packing group	II	Flash point	176ºC
Labelling	9	Density	1,5
IMDG PCB code	9036		

7. Transport

7.1. National Transport Manifest

The transport of PCB liquids and equipment within the national territory requires a transport manifest. The information to be included in this manifest is as follows:

a) General information on the carrier
    1) Name of transporter or carrier
    2) Address
    3) Telephone
    4) Fax
    5) E-mail
    6) License plate of the transport vehicle (cab, container, truck)
    7) National license to transport hazardous materials if required by the country

b) Information on the owner of the PCB equipment and oil
    1) Name of the company or individual person
    2) Address
    3) Telephone
    4) Fax
    5) E-mail

c) Information on the person/company receiving the load
    1) Name of the company or individual
    2) Address
    3) Telephone
    4) Fax
    5) E-mail

d) Information on the cargo
    1) Type of equipment or container
    2) Model
    3) Serial number
    4) KVA and voltage
    5) Total weight (kg)
    6) Volume of oil
    7) If they are containers, indicate on its four side walls UN 2315 (PCB liquids), UN 3432 (PCB solids) and Class 9 (Marine pollutant) labels

8) PCB concentration (mg/kg) indicated on each piece of equipment and oil container, including the type of analysis applied

7.2. DOCUMENTS FOR TRANSBOUNDARY MOVEMENT

To export PCB liquids or equipment to another country, a notification of transboundary movement under the Basel Convention must be prepared.

In order to do a notification of transboundary movement, the documentation indicated below has to be submitted to the competent authority of the Basel Convention in the country to which the PCB liquids or equipment will be exported.

An implementation manual and templates for the documents to be submitted can be found on the website of the Secretariat of the Basel Convention[11].

REQUIRED DOCUMENTATION:

1) Transboundary Movement Notification (TMN)
2) Movement document included within the TMN
3) Document indicating the route of the shipment including all ports starting from the port of origin, until arrival at the final destination, including transit ports
4) Non-commercial contract indicating the exporter and importer of the hazardous waste, the total weight and length of validity; the contract need not mention any indication of the cost of disposal or transportation service
5) The transboundary movement must be protected by an insurance policy, surety bond or any other security as requested by the importing country or any country of transit under paragraph 11 of Article 6 of the Convention
6) Notification and consent must be received from those transit countries through which the shipment will pass; this is part of the notification process that must be completed

Once all documents have been submitted, the competent authority of the exporting country sends the notification of the intent to export hazardous waste and the importing country's competent authority responds to the notifier.

[11] http://www.basel.int/Procedures/NotificationMovementDocuments/tabid/1327/Default.aspx

8. Temporary Storage

The main objective of proper storage of PCB liquids and waste before their treatment or final elimination is to prevent contamination of the environment and to avoid any exposure to humans. The storage process necessarily involves the implementation of safety and security measures to reduce the risks of spills and fires, including through natural disasters, which are the main threats during this process.

8.1. Selecting a Location

Selecting an appropriate location is the first step to ensure environmentally sound storage.

- Choose a site away from urban, commercial and industrial centres, especially where there are factories for food processing, medicines and easily combustible chemicals and potable water tanks, as well as recreation centers
- The location should be distant from sensitive areas such as schools, hospitals, water bodies, treatment plants, etc.
- The ground should not be floodable or aslope
- The location should not be prone to natural disasters

8.2. Structural Conditions

- The materials to be stored, such as electrical equipment, containers, etc., must be completely isolated from the environment, i.e., without contact to soil, vegetation, groundwater and rain.
- The compound should be completely roofed and single-storied.
- Good drainage and river water runoff around the storage facility must be ensured.
- The spill containment system must be a closed perimeter with the ability to contain spills with a volume greater than the liquid stored in equipment and containers (generally 50% of the total storage).
- A very good ventilation system must be in place, sufficient to ensure adequate air circulation to prevent vapour accumulation of PCB, taking into account that PCB vapours may be heavier than air. This system can be natural ventilation through openings in the top and bottom of the storage. If a mechanical ventilation system is in place, it should be controlled by a switch outside the store and be switched on a few minutes before entering it.
- All materials used in the construction of the storage facility must be non-combustible.
- The floor must be made of concrete to carry the weight of the load to be deposited as well as movement of heavy equipment and vehicles such as forklifts or cranes. The floor must be smooth, anticorrosive and it is recommended to seal it with an epoxy paint resistant to PCB, fire, liquids with a pH from 1 to 13 and a temperature of up to 70°C[12].
- Channels or dams, including a collection tank at one end of the storage area, must be in place.
- There must be an emergency exit.
- A locker room with toilets, shower, eye wash and a sink for emergencies should be close to the

[12] Manual de Manejo de PCBs para Colombia. Proyecto CERI-ACDI, 1999

storage area. Lockers for personal protective equipment and disposable clothing intended for workers who perform work on site must also be in place.

- It is advisable to install a lightning conductor and a safety electricity installation.

8.3. REGULATIONS FOR THE STORAGE OF HAZARDOUS SUBSTANCES

- The storage site must have all appropriate safety equipment, including equipment for fire protection and spills.
- Authorized personnel for entering and conducting work within the storage area must at all times wear the personal protective equipment. They must also have at their immediate disposal means of communication such as a telephone, cellular or radio, to report any incident occurring in the area.
- It must be prohibited to smoke, eat or drink within the storage area and to do work that involves a heat source.
- The PCB equipment and containers must be completely airtight, be in a well ventilated place, protected from oxidizing or corrosive materials, stowed on pallets without being stacked, accessible, with access roads for inspection, preserving corridors for internal circulation of forklifts and easily visible identification.
- Qualified staff should be assigned to be responsible for the storage area, including for the following activities:
    - daily inspections, which should be noted in a register;
    - recording equipment or containers that enter the collection centre with all information available;
    - recording of incidents such as spills, fires or other abnormalities; and
    - the staff should be trained to handle all equipment that could cause an incident.
- Security procedures should be placed in the warehouse in prominent locations.
- Next to the storage area there should be an area for the storage of materials, tools and equipment required to transfer PCB from one equipment or container to another.
- The lighting of the storage area must be connected through a device that is outside the storage area.
- There should be automatic fire detection sensors.
- The entrance should be labelled with a sign indicating the prohibition of unauthorized personnel and indicating also the type of hazardous material stored for preventive purposes.
- The store should be closed with a safety lock and telephone numbers for emergency calls should be available outside the storage area.
- It is necessary that the storage has an emergency plan that includes the fire-fighters and the emergency medical services.

8.4. CONTAINERS AND CONDITIONS FOR CORRECT PACKAGING

PACKAGING ALTERNATIVES RECOMMENDED FOR DIFFERENT TYPES OF WASTE CONTAMINATED WITH PCB

The types of containers typically used to store liquid PCB waste are the same metal drums used to package new dielectric oils from factories. These drums are considered eligible to store such wastes as they have the certified UN code to meet the requirements for resistance, thickness of the metal and sealing. When reusing these containers to package oil contaminated with PCB, it is very important to check that they have the UN code and that they are in perfect condition, i.e. no bumps, no cracks, no corrosion and that they still have covers and seals. Once the liquid has been packaged, it must be ensured that the container is tightly capped and sealed and then labelled following the instructions given above.

In the case of solid waste containing PCB, such as transformers parts, cardboard, absorbent material, clothes, etc., those can be packaged in the same metal containers mentioned above and labelled in the same way.

Transformers that have been drained should be packed, and tied together and fastened to the side walls of the container with tie downs to make sure there is no movement or tipping over during the shipment.

STORAGE AND TREATMENT OF WASTES OF USED AND EXPIRED TEST KITS

In the case of used test kits, two situations can occur:

1) The test was positive and therefore those parts of the kit that came in contact with the oil are contaminated and need to be stored and treated like PCB-suspected waste.
2) When the test was negative, the used kits should be treated as hazardous chemical waste and must be shipped to certified facilities for treatment, since the kits may contain components such as mercury. The same treatment applies for expired test kits.

8.5. LESSONS LEARNED FROM IMPROPER STORAGE

Several cases of equipment or containers containing PCB wastes have been documented where poor storage practices caused spills, meaning that PCB likely have reached groundwater or other water sources. Poor storage is often a result of lack of knowledge, resources or commitment by the authorities to prioritize this issue.

Such bad practices are likely to increase the challenges related to environmentally sound management of PCB, as they cause significant additional costs to remedy the situation, such as human health costs, remediation of the soils and investigation of the degree of contamination in the groundwater.

9. Emergency Plans

The potential risks that may arise in the case of storage of PCB liquids and equipment include spills, leaks, fires and explosions.

The most important aspects that an emergency plan should provide are:

1) Personnel that has been trained to respond appropriately to such emergencies and to carry out first aid.
2) An efficient communication system with competent authorities that need to be notified in case of emergency. A list of relevant telephone, cellular and/or radio numbers should be readily available. Relevant competent authorities include environmental governmental authorities, the fire brigade, the emergency medical services, hospitals, etc.
3) A response action plan, which should indicate the role and responsibilities of each person in an emergency situation.
4) An adequate alarm system, which has visual signs, such as flashing lights, and sound, such as sirens.
5) All required tools, equipment and materials for both the emergency and first aid, including the following:
    - Personal protective equipment (kimono, goggles, gloves, shoes, masks)
    - Appropriate fire extinguishers
    - First aid kits
    - Eyewash and emergency shower
    - Absorbent material (blankets, sawdust)
    - Brooms, shovels, rags
    - Appropriate containers
    - Pumps for repackaging

9.1. Procedure in Case of Leakage and Spills

The response in case of leaks and spills must be immediate and include the following steps:

- The staff must be equipped with clothing and accessories for personal protection.
- Stop and contain the spill source, close a valve, seal the container and apply absorbent material in the venue.
- Communicate the emergency to the authorities.
- Assess the magnitude of the emergency and proceed accordingly.
- If the spill is on a flat surface, apply absorbent blankets or sawdust and then deposit blankets or sawdust with shovels into containers that are kept for this purpose.
- If the spill was caught in a catchment tank, it needs to be pumped and deposited in containers.
- After the spill has been cleaned up, samples need to be taken to check whether the soil has been contaminated.

- If the contamination persists on the surface, it might be necessary to remove the contaminated layer to subsequently eliminate it.
- Personal protective clothing and accessories which are contaminated, need to be stored and disposed of as PCB waste.
- All contaminated tools and equipment made of metal should be stored as such, but separately from other waste to verify the possibility to decontaminate them.
- All contaminated waste arising from the operation, such as water used for washing, absorbent material, clothing, debris, etc. should be placed in airtight containers for destruction by an authorized entity later on.

9.2. PROCEDURE IN CASE OF FIRE

Although PCB are classified as inflammable liquids, they can burn at high temperatures. Therefore, they should be stored separately from other flammable products such as oil, coal, wood products and compressed gases.

During the combustion and pyrolysis of PCB, polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzodioxins (PCDDs) can be formed. These substances can be even more toxic than PCB and they can be the main hazard from a PCB fire[13].

In the case of a fire, the following steps should be taken:

- Immediately upon noticing the fire, set off the alarms.
- Notify the appropriate authorities and fire-fighters.
- The personnel assigned for this procedure must be equipped with clothing and accessories for personal protection.
- Apply suitable extinguishing material on the fire. Materials used to extinguish fires involving PCB are chemical foam, carbon dioxide, nitrogen flow and dry chemicals. Water should not be used as it will become contaminated and increase cleanup costs.
- All waste products of the fire should be cleaned similarly to the procedure detailed for spills.
- The personal protection clothes and accessories which are contaminated should be stored as PCB waste.
- Clothes worn should not be washed for re-use, but should be considered as contaminated waste.
- After the fire has been extinguished, the affected area should be closed off by fencing, to perform the clean-up.

[13] Otto Hutzinger, Ghulam Ghaus Choudhry, Brock G. Chittim and Les E. Johnston. Formation of Polychlorinated Dibenzofurans and Dioxins during Combustion, Electrical Equipment Fires and PCB Incineration. 1985. Environmental Health Perspectives. Vol. 60

10. Unsound Management

10.1. Cross-contamination

The dissemination of PCB occurs mainly through cross-contamination. During the handling of PCB equipment and containers it is therefore very important to avoid cross contamination, which can occur for several reasons:

- Mixing PCB-free equipment with contaminated equipment is a frequent cause of cross-contamination.
- Cross-contamination can also occur if PCB dielectric is replaced in a transformer by draining the liquid and refilling it with mineral oil. PCB have the ability to easily impregnate the porous parts of the transformer, i.e., wood, cardboard, paper and resins. A similar situation occurs when a transformer filled with PCB is topped up with mineral oil.
- Dielectric oils are sometimes send for regeneration or treatments performed in the field, such as filtration with filter presses or vacuum forming, in which a service provider uses equipment, tanks, pumps and hoses already contaminated with PCB for other customers.
- Another very important form of dissemination of PCB is the transfer of oil and contaminated equipment to recyclers or scrap merchants. In addition to disseminating PCB, is also a very effective way of contaminating soil and water, as those who usually receive these materials do not have adequate stores and often do not apply safety rules for handling PCB. These two activities, the sale of scrap for smelting and of oil for refining or burning can grow into serious environmental problems, as they constitute a cause of release of emissions of dioxins and furans into the environment.

It is important to note that a small volume of PCB oil is enough to contaminate large volumes of mineral oil to over 50 mg/kg.

10.2. Soil Pollution

The contamination of soils may, among others, occur as a consequence of cross-contamination, accidental spills, losses during transport, leaks or fires in equipment or products containing PCB, and uncontrolled thermal destruction. PCB are stable until 170°C and start to decompose between 200°C and 450°C, evaporating dioxins and dibenzofurans. Dioxins are have been shown to be carcinogenic.

The initial basic steps that need to be taken to manage a soil area that has been contaminated by PCB include preventing human contact with the contamination (isolating the area), removing the contamination (it can be dug up), and containing the contamination in the area (it can be backfilled with clean soil). The contaminated material removed must be put in a safe storage area for later treatment. There are several techniques for the treatment of contaminated soils, such us incineration, biodegradation, thermal desorption, removing with solvent, etc.

10.3. Unsound Disposal

Prior to its strict regulation, PCB were discharged routinely without taking necessary precautions. Sometimes PCB were voluntarily released into the environment, for example to reduce dust emissions from unpaved roads. As a result, large volumes of PCB were introduced into the environment through open or incomplete burning; vaporization of paints, coatings and plastics; direct input or leachate into

collectors or streams; disposal in (unsafe) landfills; and other unsound disposal practices. In some cases, PCB continued to be illegally disposed of.

10.4. ECONOMIC COSTS

Non-compliance with the Basel and Stockholm Conventions is likely to cause significant costs, including economic costs in the health system and for the environment[14]. The costs will rise if appropriate steps are delayed.

As an example and to have a parameter for calculating such costs, an average transformer occupies an area of one square meter, so in case of leak of PCB, at least that square meter floor will be affected. If a collection centre has about 100 transformers with PCB contamination that leak and that are improperly stored, it is expected that the area that could become contaminated is at least 100 square meters. As time passes, in addition to contaminating the soil, the contamination could reach groundwater or surface water, affecting also the aquatic flora and fauna. The pollution will also reach humans. At this point, economic, environmental and health costs will increase considerably.

[14] MVADT, "Evaluación de las Implicaciones Sociales y Económicas del uso y reducción de los COP", Colombia, 2007, ISBN 978-958-97978-7-7.

11. Frequent Causes of Accidents

In the case of in-service equipment, the most frequent causes of accidents are voltage spikes and insulation defects that cause an electrical arc that releases hydrochloric gas, which increases the internal pressure, produces a crack in the shell and causes leakage of insulating material as liquid or aerosol. In addition to the emission of PCB, significant amounts of hydrochloric acid can be produced, which can represent a problem when carrying out emergency work.

Accidents can also be induced by physical problems that break the seal or oxidation points of the casing causing leakage of PCB through the exposed points. If the equipment does not have a containment system, the PCB can easily disperse over a large area and even penetrate rapidly into the ground with the possibility of reaching groundwater. Such accidents can occur in equipment in service, out of service or even when being transported.

In cases where fires or thermal decomposition of PCB occur, due to the presence of oxygen, the decomposition of PCB may generate dioxins and furans. The smoke and soot containing these compounds can be dispersed widely.

The origin of a fire in a transformer can be a short circuit or voltage overload. An example of the latter was what happened in Reims in 1985, when a transformer containing PCB exploded in the basement of an apartment building of 6 floors. As a result of the explosion the smoke spread through the staircase, the waste disposal and ventilation duct upstairs to all floors, which required the complete evacuation of the building.

An example of a fire caused by a short circuit occurred in a 18-story building in Binghampton, USA, in 1981. The circuit breaker caused the pyrolysis of 400 litres of PCB contained in a transformer. The fire produced a large cloud of smoke that spread through the ventilation system causing contamination of the entire building. In addition to an important contamination by PCB, high concentrations of dioxins and furans were also generated, which is why the building had to be evacuated completely. The decontamination of the building took 4 years and incurred costs of USD 30,000,000.

When a transformer with PCB is exposed to high temperatures, it is very likely that a decomposition of these compounds to produce hydrogen chloride and carbon monoxide takes place. The chlorine gas can cause serious irritation of the respiratory tract, areas of exposed skin and mucosa of the eyes, which can cause pharyngitis, laryngitis, bronchitis and eye inflammation. If the concentrations are very high there is a risk of acute pulmonary edema. Therefore, we recommend never sniffing a transformer that has been exposed to high temperatures or that is damaged.

Annex A: Important and Useful Sources of Information

1) Secretariat of the Stockholm Convention on Persistent Organic Pollutants: www.pops.int
2) Secretariat of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (UNEP/SBC): www.basel.int
3) European Commission: www.europa.eu.int
4) Basel Convention Coordinating Centre for Training and Technology Transfer for Latin America and Caribbean: www.desechospeligrosos.org
5) Environmental Protection Agency, United States of America: www.epa.gov
6) Basel Implementation Manual: http://archive.basel.int/pub/pub.html
7) Como eliminar falsos positivos de PCBs en aceites dieléctricos: www.miradoralsur.com
8) United Nations Environment Programme (UNEP): www.unep.org
9) Centers for Disease Control and Prevention: www.cdc.gov//nisoh
10) How to read UN Packaging Codes: www.dabox.com
11) Customer Guide to UN Packaging: www.foxvalleycontainers.com
12) PCB Management and Disposal under the Stockholm Convention on Persistent Organic Pollutants: www.unece.org/trans/danger/danger.htm
13) Dexil Corporation: www.dexil.com

Annex B: Glossary of Terms

Askarel = Trade name of PCBs cooling fluid (USA, Monsanto).

Ballast = Control device located inside a fluorescent, mercury, sodium and neon lightning. Among others it is comprised of a small capacitor, which could contain PCBs.

Bioaccumulation = Property of certain chemicals to accumulate in living organisms.

Biodegradation = Process by which an organic substance is decomposed into simpler ones by the action of microorganisms.

Capacitor / condenser = Device that collect and maintains an electric charge.

Closed application = Applications in which PCBs are in a totally enclosed equipment. Under these conditions, PCBs only enter the environment in limited cases, such as leaks or spills of equipment (examples: transformers, capacitors).

Conference of the Parties = the supreme organ of a treaty made by all its parties.

Congener = In the case of PCB, different configurations of links and number of chlorine atoms, which cause different chemical properties and toxicity.

Contaminated oil = Dielectric oil contaminated with PCBs at a concentration generally below 500 mg/kg.

Dechlorination = Removal of chlorine atoms from PCB molecules.

Decontamination = The process of removing contaminants from a substance or alterating their chemical nature to transform them into harmless substances.

Dielectric oil = Insulation oil, which has the property of resisting an electrical potential gradient and preventing the passage of an electric current.

Dioxins = generic name for the chemical group of polychlorinated dibenzo-p-dioxins (PCDD) that may originate from the combustion of materials containing PCBs.

Hazardous waste = A substance that due to its corrosive, reactive, explosive, toxic, flammable, radioactive or infectious characteristic(s) causes damage to human health and the environment.

Heat transfer fluid = Oil used to transport heat or cold between two areas of a surface of a process or the surface of an equipment.

mg/kg= Concentration unit, expressed as milligrams per litre or milligrams per kilogram.

Persistence = The capacity of a chemical to remain unchanged in the environment for a long period of time. Usually described in terms of average life.

Persistent Organic Pollutants = organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic process. They are persistent in the environment, are capable of long range transport, they bio accumulate in human and animal tissue, and bio accumulate in food chains and have potential significant impacts on human health and the environment.

Polychlorinated biphenyls = organic compound composed of two benzene rings bonded together by a chemical bond with carbon and chlorine atoms substituting hydrogens. Pyrolysis = a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen).

Transformer = device used to raise or lower the voltage. They are used in power generating facilities, substations, buildings, etc.

Annex C: PCB Trademarks

Trademark	Manufacturer or Origin
Asbestol,	American Corp, USA
Adkarel	
Asbestol,	Monsanto, USA
Askarel,	UK and USA
Auxol,	Monsanto, USA
Aceclor,	ACEC, Belgium
Aceclor,	France
Arochlor,	Monsanto, USA
Apirolio,	Caffaro, Italy
Apirolia,	Caffaro, Italy
Aroclor,	UK and USA
Areclor (t)	
Arubren	
ASK	
Bakola 13,1	Monsanto, USA
Biclor (c)	
Chorextol	
Chlorextol,	Allis Chalmers, USA
Chloroextol,	Allis Chalmers, USA
C(h)lophen A30	Bayer, Germany
C(h)lophen A50	Bayer, Germany
Clophen A60	
Clophen Apirorlio	
Chlorphen	Jard Corp, USA
Chloresil	
Chlorintol	
Chlorinol	USA
Chlorinated Diphenyl	
Clorphen (t)	
Deler	
Delor	Czech Republic
Dialor (c)	
Diaclor	USA
Diachlor	Sangamo Electric
Diachlor	Sangamo Electric
Diaconal	
Diconal	
Disconon (c)	
Dykanol	USA

Duconal	UK
DK	Italy
DP 3, 4, 5, 6.5	
Educarel	
EEC-18	Power Zone Transformer, USA
Electrophenyl	PCT, France
Elaol	Bayer, Germany
Elemex (t, c)	
Elexem	McGray Edison, USA
Eucarel	
Fenclor 42, 54, 64, 70	Caffaro, Italy
Hexol	Russian Federation
Hivar (c)	
Hydol	USA
Hyvol	Aerovox, Italy
Inclor	
Inclar	Caffaro, Italy
Inerteen 300, 400, 600	Westinghouse, USA
Kan(e)chlor (KC) 200-600	Kanegafugi, Japan
Kanechor	
Kaneclor	
Kaneclor 400	
Kaneclor 500	
Keneclor	
Kennechlor	
Leromoli	
Leromoll	
Magvar	
MCS 1489	
Montar	
Nepolin	USA
Niren	
No-Famol	
No-Flamol	Wagner Electric, USA
NoFlamol	
Non-Flamable Liquid	ITE Circuit breakers, USA
Phenoclar DP6	Baylor, Germany
Phenoclor DP6	Prodelec, France
Plastivar	UK
Pydraul	USA
Pyroclar	Monsanto, UK
Pyroclor	Monsanto, UK

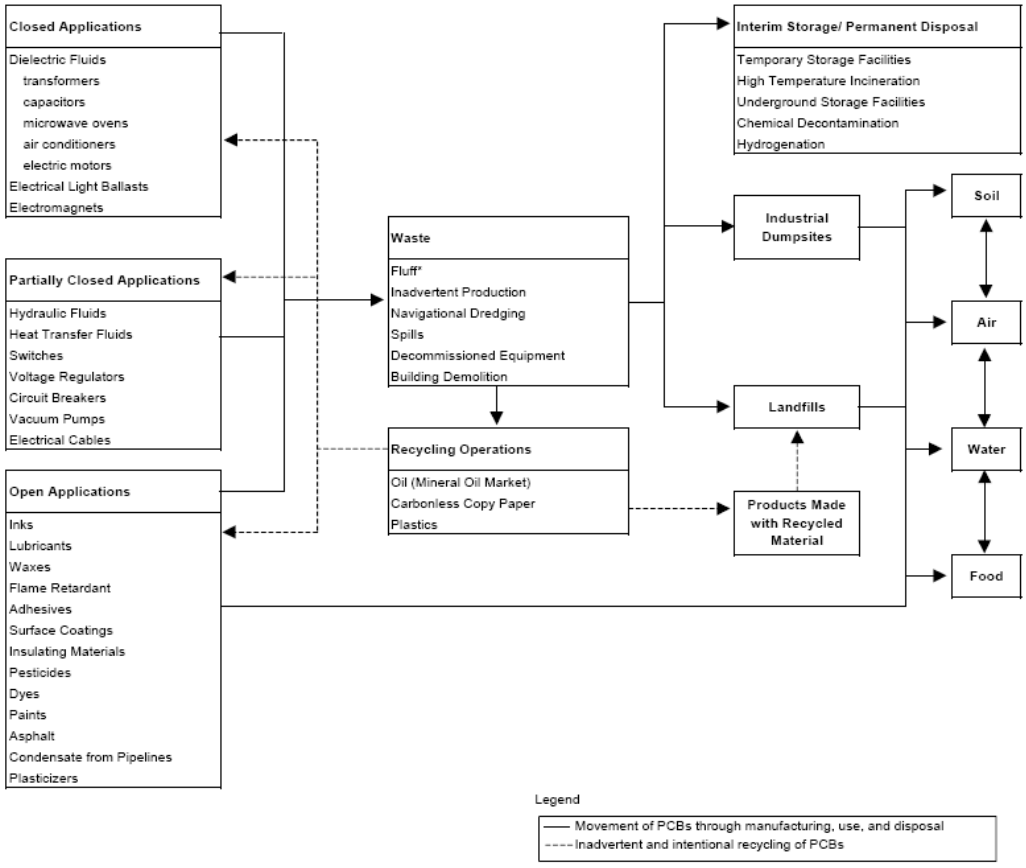
Pyrochlor	
Pyranol	USA
Pyronal	General Electric, UK
Pysanol	
Physalen	
Phyralene	Prodelec, France
Pyralene 1460	Prodelec, France
Pyralene 1500, 1501	Prodelec, France
Pyralene 3010, 3011	Prodelec, France
Pyralene T1	Prodelec, France
Pyralene T2	Prodelec, France
Pyralene T3	Prodelec, France
Safe-T-America	
Safe-T-Kuhl	Kuhlman Electric, USA
Saft-Kuhl	
Sant(h)osafe	Mitsubishi, Japan
Santosol	
Santvacki	Monsanto, USA
Santovac	
Santovac 1	
Santovac2	
Santowax	
Santothern FR	UK
Santotherm	France
Sant(h)othern FR	Mitsubishi, Japan
Saut(h)otherm	Mitsubishi, Japan
Siclonyl (c)	
Solvol	Monsanto, USA
Sorol	So(1) vol, USSR
Sovol	So(1) vol, USSR
Therminol	USA
Therminol FR	USA
Terpenylchlore	PCT, France

Annex E: Transformer Brands that Used to Use PCB

Brand	Country of origin
Westinghouse	USA
General Electric Company	USA
Research-Cottrell	USA
Niagara Transformer Corp.	USA
Standard Transformer Co.	USA
Helena Corp.	USA
Hevi-Duty Electric	USA
Kuhlman Electric Co.	USA
Electro Engineering Works	USA
R.E. Uptegraff Mfg Co.	USA
H.K. Porter	USA
Van Tran Electric Co.	USA
Esco Manufacturing Co.	USA
British Power	UK
Transunal	UK
AEG (Divisions in Germany)	GERMANY
Trafo Union (TU)	GERMANY

Source: Guidelines for the identification of PCBs and Materials Containing PCBs, UNEP,1999.

Annex F: PCB Applications



* Fluff is waste in the form of upholstery, padding, and insulation materials produced from the shredding of appliances and automobiles that become saturated with PCB-containing oils and fluids.

Source: Guidelines for the identification of PCBs and materials containing PCBs – First Issue, August 1999, United Nations Environment Programme (UNEP)