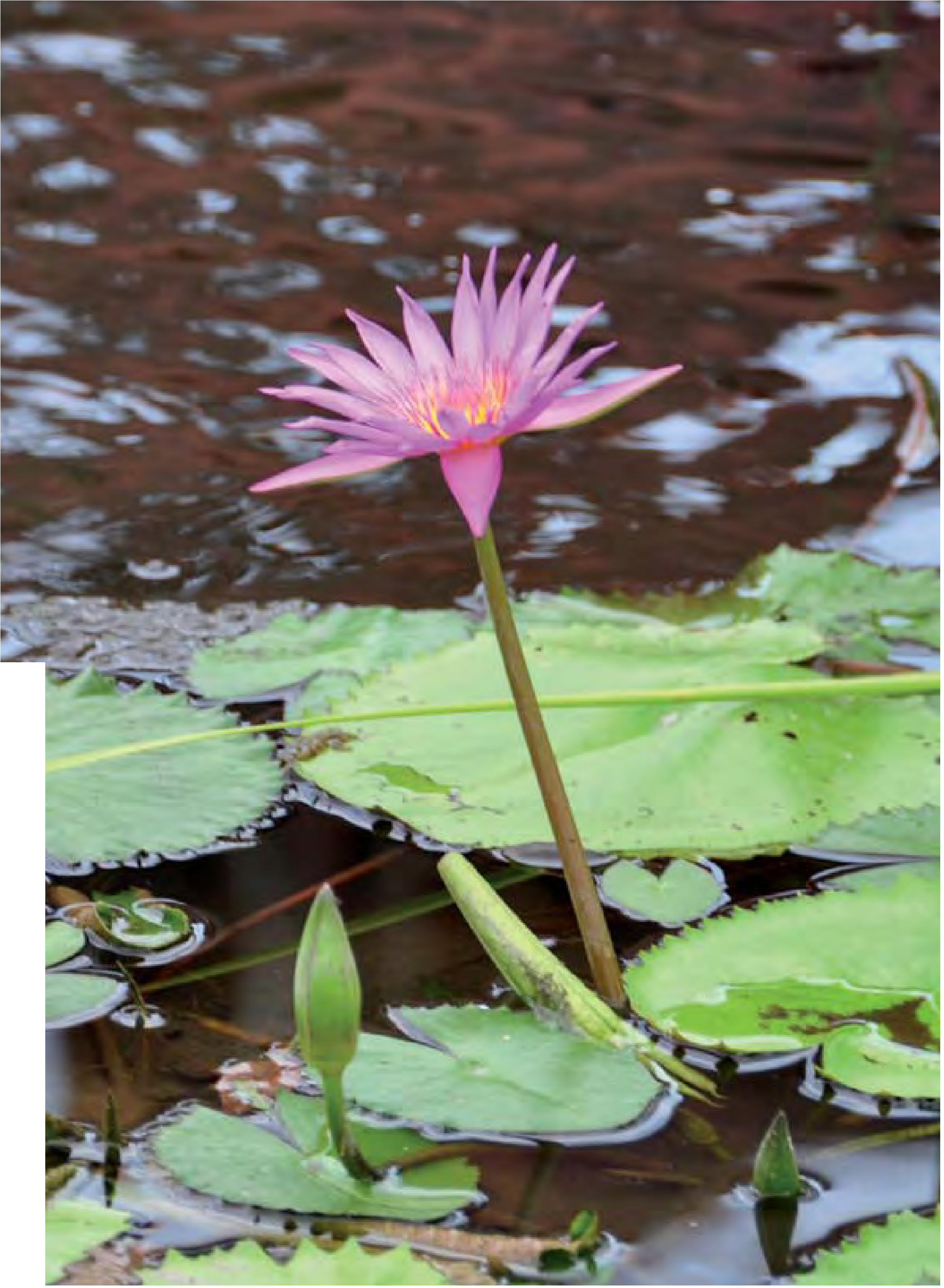


Inventories of PCBs
An Expert's Point of view

By Urs K. Wagner

Introduction

Some Nigerians treat their skin with PCB transformer oil to leave it soft and to gradually achieve a bleaching effect. Others in Honduras use PCBs as a cure against arthritis. In Sri Lanka, certain welders prefer working with PCB oils because these are cheaper than ordinary cooling oils. In several African countries, cooking oil on local markets originates from "transformer cannibalism" and contains sometimes pure Askarel or Pyralene PCB formulations. In Switzerland, the consumption of certain fishes from specific rivers was forbidden in the spring of 2010 due to PCB concentrations far above the allowed maximum levels in Europe. Recently, it has been reported that 90% of German sheep livers have concentrations of PCBs above accepted levels. High PCB concentrations originating from a transformer treatment plant have recently made vegetables inedible in a big German city. The world started tackling the PCB problem many years ago, however, the environmentally sound management and elimination of PCBs on a global scale remains a real challenge. Reliable PCB inventories are the first step in professional PCB management and will help to meet the aims and deadlines set in the Stockholm Convention and eventually rid the world of PCBs.

Production and use of PCBs

Industrial PCB production started in the United States of America (USA) in the 1930s and, after the 2nd World War, Europe also launched its PCB products. In the late 1960s, maximum production was reached with over 60,000 tonnes per year. Due to several severe harmful incidents related to PCBs, production was stopped in most countries after 1983 except for some Eastern European countries. The Russian Federation, for example, only stopped production between 1987 and 1993. The total world production of PCBs between 1929 and 1989 was approximately 1.5 million tonnes.

In most countries, PCBs have never been produced. However, PCBs have been imported and used as technical mixtures and also used in parts of various products, including electrical equipment. Usually, it is not known how much PCB was imported into a country. Furthermore, PCB containing equipment was often shipped to developing countries in the frame of donations without declaration of the POPs content, even after the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal had come into force. Even in the USA and Western European Countries, it is often not possible to provide precise information on the existing amounts of PCBs. There are no reliable data available either on the total imports or on PCB quantities still in use. This is also true for uses in electro-technical equipment; in gas, water and oil pipelines, steel bridges, tanks and a range of other steel applications as corrosion protection paint; in buildings as sealants; and small devices as ballasts.

The most important piece of information though, is where PCBs have been distributed and what has been contaminated. The magnitude of the problem – which is even more widespread due to inappropriate handling and treatment - can only be understood when the extent of the contamination is known.

(cont. on page 10...)

Develop and implement administrative control systems that may limit further cross contamination of PCBs to clean oil, equipment and to the environment

Research suggests that nearly half (48%) of the PCB production was used for transformer oil; about 21% for small capacitors; 10% for other "nominally closed" systems; and approximately 21% for "open uses". Although it is estimated that 97 % of the global use of PCBs have occurred in the Northern Hemisphere it must be considered that in the course of the last 70 years a considerable quantity of PCBs found their way to the Southern Hemisphere, both intentionally and unintentionally.

Based on experience in the USA and Western Europe, it can be assumed that PCBs have permeated all electrical systems except those that have been hermetically sealed off from the rest of the world. If PCBs have been imported into a country, the chemical has most likely worked its way throughout the electrical system and other relevant sectors. The degree to which a given electrical system has been contaminated can vary and the range of possible applications of PCBs is extremely wide.

List of some closed, partially open and open applications of PCB

Closed, partially open, and open applications of PCB
Closed systems Insulation and/or cooling fluid in transformers Dielectric fluid in capacitors Switches
Partially open systems Heat transfer fluids Hydraulic fluid in lifting equipment, trucks and high pressure pumps Vacuum Pumps Voltage Regulators Liquid Filled Electrical Cables Liquid Filled Circuit Breakers
Open systems Paints Lubricating fluid in oils and grease Water-repellent impregnating agent and fire retardant for wood, paper, fabric and leather Laminating agent in paper production Additive in glues, sealants and corrosion protection coatings Carrier for insecticides Polymerisation catalyst support for petrochemicals Immersion oils for microscopy Pesticide Formulation Cable coatings/casings

Scrap yard in a repair shop in Paraguay

Due to non-expert management of contaminated material, widespread cross-contamination has occurred. PCBs teach us a lesson on how humans can cross-contaminate all compartments of the environment including soil, water, sediments and air, by uncontrolled release and migration of one of the initial twelve POPs. Specifically, in developing countries and countries with economies in transition there is no proper handling of phased-out electrical equipment in place. For workers, an electrical device which cannot be repaired and reused does not represent any commercial value and therefore it is handled as scrap with little or no precaution for the safety of human health and the environment.

Without data indicating where there are PCBs, the entire system is suspect. This is the situation in many locations around the world. Collecting data on the specific kind of PCB contamination and the extent of it is important if the risks of PCB exposure are to be reduced. In the long-term, priorities must be established and budgets put in place to ensure removal from use and replacement of PCB-containing and contaminated equipment. If the goals of phasing out PCB-containing equipment by 2025 and establishing environmentally sound management of PCBs by 2028 are to be achieved, a substantial effort will be required to undertake comprehensive and reliable inventories of all contaminated equipment, organize the data collected, set the right priorities, ensure safe handling throughout all further stages and track the equipment until the PCBs are safely managed or destroyed. If the lessons learned in the western world are an indication, this process is a difficult one as it will require countries across the globe to be immediately active in implementing the process. Otherwise, this exercise could take much longer than anticipated.

A trustworthy inventory might be the hardest task to accomplish, but at the same time it is crucial to have reliable and complete data before embarking upon storage, treatment or disposal programmes. Experience shows that too often, decisions have been made based on assumptions made from preliminary information rather than from reliable and detailed inventories.

1,300,000 Tonnes of PCBs produced globally between 1929 to 1993

STATUS OF PCB INVENTORIES GLOBALLY

Developed countries

PCB equipment has been gradually identified, quantified, analysed and replaced in developed countries. In Switzerland, for example, the first inventory of PCBs in electrical equipment started in 1983, and by August 1998 all PCB-containing equipment had to be eliminated. In general, the aims were reached. However, there are relevant quantities of small- and low-voltage PCB capacitors still in use and occasionally, formerly unknown PCB sources are detected. Today, many countries in the Northern Hemisphere focus on PCBs in open systems considering it now as the most problematic source of exposure. Experiences in Switzerland show that many public buildings constructed between 1955 and 1983 often contain PCBs in their elastic sealants (caulks) and paint applications (on steel and concrete). In 2003, the Swiss Federal Office for the Environment published a directive requiring investigations about the PCB content in such buildings and calling for special measures to protect inhabitants, users, workers and the environment. Similar regulations and guidelines exist in the USA, Sweden, Norway, Germany and Austria.

Make use of the opportunity when doing an inventory to also consider open systems

Developing countries

Whereas PCBs in closed systems are generally "under control" in the developed countries, a significant amount of the existing PCB-containing or contaminated equipment is still in use in developing countries and countries with economies in transition, due to the high logistical and financial burdens involved in safe and environmentally sound replacement of PCB-contaminated devices.

Most of the Parties to the Stockholm Convention in all regions worldwide have compiled preliminary inventories in the development phase of their National Implementation Plans (NIPs). However, differing inventory methods and approaches have been used. Some countries only estimated the number of suspected PCB-contained devices; some calculated the weight of waste containing PCBs, based on the usually poor feedback from questionnaires; whereas others did not only focus on transformers and capacitors but also analysed samples from suspected contaminated sites.

(cont. on page 24...)

Standard Operating Procedures (SOP) should be established for the inventory process, especially if the inventory is compiled by several field teams

Obsolete stocks of PCB equipment have not been appropriately inventoried yet

Inventory taking training in the field in Vietnam

PCB inventories should have been finalized in the course of the NIP development and preparation. It is obvious, however, that the complexity of PCB inventories was underestimated including the proportion of financial and human resources needed to complete these inventories.

In most countries comprehensive national inventories could not be achieved within the available timeframe and budgets.

PCB inventories invariably do not reflect the contribution from the informal sector and the validity of the inventories is reduced where the informal sector represents a significant proportion of economic activity. It is also unclear to what extent the contribution of the private sector and small consumers in general are included in these inventories. Usually, the activities focus on energy production, transmission and distribution utilities. Also, it seems that a majority of the inventories are focused on transformers but not capacitors and other electrical devices with volumes greater than 5 litres.

The preliminary inventories or the various pilot projects in the regions however, are still very useful as they serve as a basis for future detailed inventories and provide basic information in the sense of a "snapshot of the problem" allowing the Parties to better understand the complex task of a complete PCB inventory.

Furthermore, only a fraction of this equipment has actually been sampled, tested and, when necessary, verified by laboratory analysis. Assessments of the real PCB situation at the national level show that the actual PCB quantities often dramatically differ from preliminary investigations. Luckily, the figures in reality are not necessarily higher than estimated figures. Often the detailed inventory reveals that the problem is smaller than estimated and considerable funds can be saved as extensive management activities are not required. A positive spin-off from undertaking a professional inventory is awareness-raising - particularly in the maintenance and repair sector, in oil recovery and for scrap and recycling industries - which prevents further unintentional cross contamination of clean oils from PCB-contaminated oil and solid material.

In some Asian countries, PCBs have been spreading rapidly in the environment due to indiscriminate human activities and lack of awareness. Waste oil is often used as fuel in brick plants and, through illegal trade in transformer oils to retail sellers and transformer auctions, PCB oils have entered into the open market. This is also true for many African countries. Because of the cheaper price, welders prefer using PCB oils instead of the recommended coolant oil.

In various Latin American countries, waste oils from transformer repair shops are used in the production of concrete poles. The steel channels are lubricated with the oil by hand before the concrete is poured into them. If the waste oil contains PCB, this "recycling" can contaminate the concrete. The workers are not protected and are exposed to the PCB oil. Due to the lack of awareness of the health risks from PCBs, it has become difficult to control such situations.

From 2003 to 2007, PCB inventory projects, funded through the Canada POPs Fund, France, Switzerland and the USA, were launched in fourteen Southern African Development Community member countries. These projects brought to light and reported on many cases of misuse of PCB-contaminated oils. It was further recognized that such misuse in the informal sector potentially adversely affects human health. There is lack of public awareness on PCB-related issues, technical expertise, as well as PCB regulations and guidelines. These reports even acknowledged that the import of PCB-containing equipment was still possible in some countries. However, in most African countries, the PCB inventories are still very basic, based on estimations from limited data collection activities and some screening results. Very often, those screening feedbacks are not based on chemical testing but simple density tests or the Beilstein method which is later explained in the screening section of the steps to take for an inventory.

Importance of proper inventories

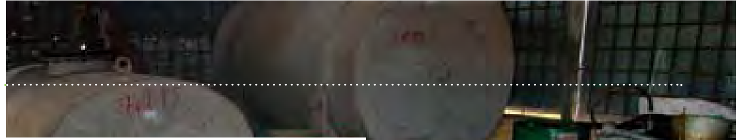
In the efforts around the world to eliminate PCB-contamination in electrical equipment - as well as from other sources - reliable identification and detection will be the key starting point. In order to decide on the best cost-effective and environmentally sound elimination or treatment options for a specific country, factual information about the nature and extent of the PCB problem is required.

As already demonstrated in many Western, Asian, Pacific, African, Central European and Latin American countries, the effective integration of field screening methods into the inventory proceedings can result in substantial cost savings in later stages of managing PCB-containing or contaminated equipment.

The more reliable information is and the faster it becomes available, the sooner contamination can be stopped. Consequently, reliable testing can be done at reduced costs; the cleanup process initiated and more money made available for remediation and elimination activities. Generally, we have to consider the status and quality of PCB inventories and that PCB management varies extensively between the countries and regions. Consequently, there is still a long way to go to achieve the 2028 aims.

Existing PCB inventories need to be updated e.g. by considering and including stakeholders not previously covered, improving the accuracy of existing data, by carrying out chemical analysis of the positively screened samples, labelling surveyed equipment using a regionally harmonized label and maintaining the inventory using a regionally harmonized database.

(cont. on page 26...)



Consider spare oil as potential PCB source

In the Central and Eastern European Region, Moldova has achieved a measure of success in how it approached a PCB inventory. Efforts towards a PCB-free future started in May 2001, when the country signed the Stockholm Convention. A number of actions have subsequently been taken that aims at a reliable and complete inventory of PCBs.

Filtering equipment of used oil, possibly contaminated

Do you know where your waste oil goes?

Process of concrete pole production using waste oil

Treat owners of PCB suspected equipment as partners not as the enemy. An aggressive ("police mentality") is often counter-productive

Communication is a crucial factor during all phases of an inventory or assessment project

Stakeholder participation

There is usually little or no interest by stakeholders and especially industry to participate in the identification process. The main reason why industry and small consumers are afraid to provide information or access to their sites is their fear of being sanctioned if PCB is found on their premises. Furthermore, stakeholder commitment is limited because they do not understand their role in the inventory process or the person contacted is a low-level officer.

Government ministries in developing countries often have only few multidisciplinary staff and it is difficult to have a person solely dedicated to such an inventory project. No obvious advantages are seen. Therefore, an important element of an inventory campaign is related to awareness raising and specific training on PCB issues. This should ideally involve all stakeholders from the decision-making bodies to the mid-management level and even those who might be exposed to PCB in the workplace.

It is also important that owners of electrical equipment interact with "PCB inventory Field Teams" who do not inspect their sites like "policemen" but to whom they can relate instead as friends, and with whom they may share valuable information and consult on what to do if the presence of PCBs is confirmed. This may end in win-win situations, as owners gain time in order to plan budgets and possibly replacement for contaminated equipment, get access to future phase-out projects and take action to prevent exposure to staff.

Governmental bodies will fail with their complex tasks without active participation and assistance of the utility companies and other private sector bodies that own PCB-contaminated equipment.

Of course the initial sampling, screening and verification activities usually focus on the largest owners of potentially PCB-contaminated equipment, such as electricity utilities. Thanks to their knowledge and experience they are valuable partners in the inventory process. But the process of identification must also involve industry and smaller consumers. These entities may also possess a significant number of transformers and capacitors when pooled. Additionally, smaller capacitors usually have higher concentrations of PCBs in the oil mixture

Non-governmental organizations play an important role in their countries and should preferably be part of Steering Committees for relevant projects. However, in many countries their lack of knowledge and capacity limit their active participation resulting in their exclusion from such tasks.

Required resources for inventories

In most countries there are local experts (electrical and chemical engineers) available who have substantial knowledge about PCBs. Unfortunately, the knowledge is often of a theoretical nature only. There is a lack of practical PCB management know-how. On the other side, budgets for well experienced, international, senior consultants are usually too low, simply because the complexity of PCB management is substantially underestimated. Budget savings for consultancy often result in cost increases in the later stages of PCB management.

Due to the unavailability of PCB test kits in countries and the high cost of PCB analyses by gas chromatography (GC), the number of oil samples to be tested is usually low. This also applies to the purchase of appropriate sampling materials like glass vials, pumps, absorbents, tools, personal protective equipment (PPE), etc. Efforts should thus be made to allocate budgets for the sufficient purchase of appropriate sampling and screening material.

All preliminarily inventoried devices and sites should be subject to further validation including physical site investigation, sampling, screening and, if necessary, verification by laboratory analysis. It should be considered that the investment into a reliable PCB assessment may result in significant cost savings in later stages of the management process due to reduction in unintentional cross-contamination and implementation of country-tailored management systems.

Step-by-step approach to completing a PCB inventory

The aim of the inventory is to identify, quantify and maintain records of PCB oils, equipment and the materials prone to containing or being contaminated with PCBs. This information is indispensable when preparing a plan for PCB management, which should encompass the entire lifecycle of these products.

1. Develop a guideline

A guideline or manual for PCB management, including the identification of PCB equipment, should be prepared to address all issues related to the identification process. Procedures for the inventory, as well as the sampling and screening must be established. Such inventory procedures should also consider "soft criteria" such as the specific culture and attitudes of the specific country.

Links to relevant PCB guidelines
UNEP Manuals on PCBs - **http://www.chem.unep.ch/pops/newlayout/repdocs.html**
UNEP Manuals on POPs - **http://www.chem.unep.ch/pops/newlayout/repdocs.html**
Stockholm Convention: Training Tool on the Technical Guidelines for the Environmentally Sound Management (ESM) of Persistent Organic Pollutants (POPs) wastes **http://chm.pops.int/Portals/0/flash/popswastetrainingtool/eng/index.html**
Stockholm Convention: BAT/BEP Guidance: Draft guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C **http://www.pops.int/documents/guidance/batbep/batbepguide_en.pdf**
Basel Convention: Technical Guidelines: Technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with polychlorinated biphenyls (PCBs), polychlorinated terphenyls (PCTs) or polybrominated biphenyls (PBBs). **http://www.basel.int/pub/techguid/tg-PCBs.pdf**
Basel Convention: Training Manual: Preparation of a National Environmentally Sound Management Plan for PCBs and PCB-Contaminated Equipment - **http://www.basel.int/pub/pcbManualE.pdf**
Catalogue published by the Australian and New Zealand Environment and Conservation Council (ANZECC) on PCB contamination in capacitors: **www.deh.gov.au/industry/chemicals/scheduled-waste/pcbs/pcbid.html**.

Sources of information to assist in the development of a guideline

In order to prevent the future accumulation of PCBs, measures such as the controlling of cross-border movement of second-hand transformers should be implemented and existing laws and regulations should be reviewed to identify where additional provisions relating to PCB may be needed.

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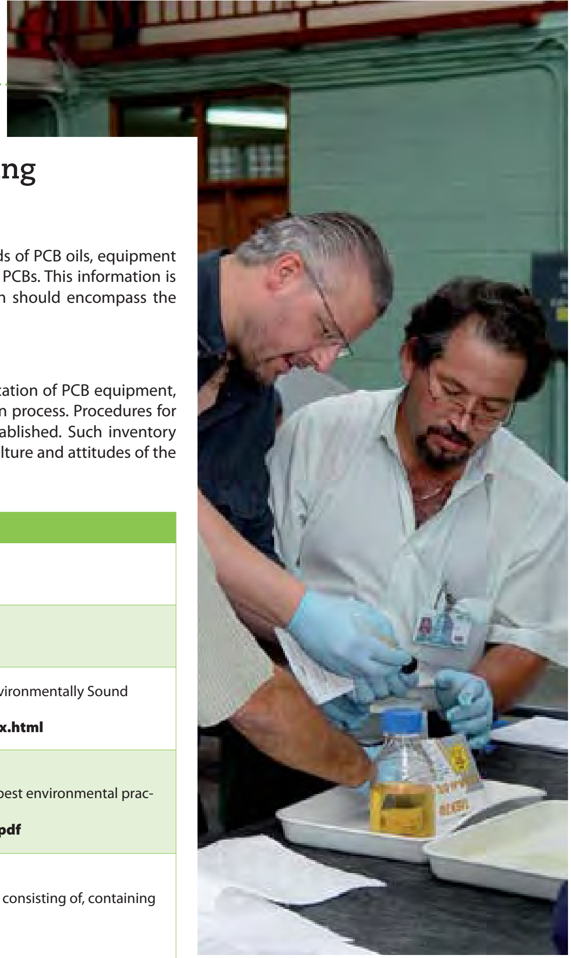
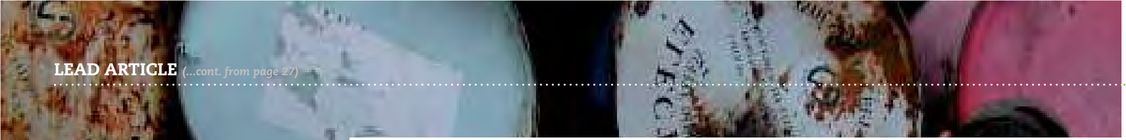


Screening training in an electricity utility

Inventory plans should consider "Soft Criteria" such as the specific culture and attitudes found in each country respectively



2. Send a questionnaire to potential stakeholders

A questionnaire should be developed and sent to the potential owners of PCB equipment. These potential owners fill in the form and return it to the responsible PCB project team.

Potential stakeholders	
Electric utilities	Hospitals
Industrial facilities	Research laboratories
Railroad systems	Manufacturing plants
Mining industry	Waste water discharge facilities
Army installations	Car service stations
Residential or commercial buildings	Small/medium sized companies
Holiday resorts / hotels	Airports
School buildings	Wood processing companies
Cold storage depots	Exporters

At the beginning of the inventory process, there is often no regulation regarding PCB management, which means that the owners of such equipment are not obliged to participate in an investigation. In order to stimulate participation in the identification process, it will be useful to offer free sampling, screening and verification. For instance, in the former Yugoslav Republic of Macedonia, such an incentive based on a bilateral donation was very successful. Thanks to that support, many companies participated in the identification process and it also allowed for smoother collaboration in the later stages of the inventory. If limited information or no response is obtained, the PCB project team should get in touch with the potential owners of PCB equipment. The information gathered from the completed questionnaires will be used as a basis for site investigations.

3. Carry out physical site inspection

Sites where PCB-containing equipment may be found should be inspected by field teams or engineers included in the PCB project team. During the inspection, the information provided in the questionnaires shall be checked and further data regarding the particular type of PCB equipment or PCB waste collected and recorded. These include: Kilovolt-ampere (KVA) rating, brand name, fluid quantity, type of fluid, location of the device, serial number, PCB concentration, year of manufacture, and weight.

During the visit, the site shall also be checked for visual contamination. An inventory is always a chance for preventive maintenance.

In order to facilitate the inspection, country-tailored inventory forms shall be developed which include all data necessary for the determination of the parameters needed for the evaluation of the risk associated with PCB equipment and waste. Also, ID numbers shall be determined for each piece of potentially contaminated equipment and waste. Each owner of potentially PCB contained equipment should affix the ID number to it and fill in the inventory form. If a decision on the presence of PCBs cannot be made based on the available data, then such equipment has to be sampled.

(cont. on page 40...)

Inventory of transformers in Paraguay

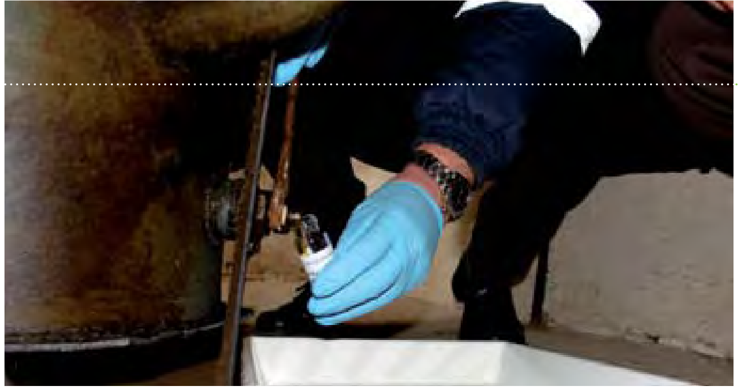
A	Informacii za kompanijata , lokacijata i oprema koja sodr`i/ e kontaminirana so PHB		
1	Ime:		
2	Adresa:		
3	Adresa na lokacijata: (ako e razli~na od onaa popolneta vo A2)		
4	Telefon:		
	Faks:		
	E-mail:		
5	Ime/pozicija na liceto za kontakt:		
6	Od kakov tip e kompanijata/industrijata/ proizvodstvoto na specifi~nata lokacija:		
7	Javno ili privatno pretprijatie?		
8	Lokacija:	Industriska zona	
		Drugo urbano podra~je	
		Ruralno podra~je	
9	Vkupen broj par~iwa od opremata na lokacijata:	Transformatori	
		Kondenzatori	
		Drugo	
10	Oprema koja e vo upotreba i sodr`i/ kontaminirana so PHB	Broj na sadovi	
		Vkupna te`ina na opremata (kg)	
		Vkupna koli~ina na te~nost (kg ili litri)	
11	Oprema koja e nadvor od upotreba ili otpad koj sodr`i/kontaminiran so PHB	Broj na sadovi	
		Vkupna te`ina na opremata (kg) Vkupna koli~ina na te~nost (kg ili litri), Vkupna koli~ina na kontaminiranata po~va i objekti (kg ili m^3)	
12	Postoe~ki akcionen plan za eliminacija na PHB? - akcionen plan koj e predviden, no ne e zapo~nat - porane{ni aktivnosti za otstranuvawe na otpadot - vremenska ramka na programata		
13	Popolnil:	Ime i Prezime	Potpis i Pe~at / Datum

Inventory form used in the Former Yugoslav Republic of Macedonia

7,700
Tonnes of PCBs and PCB-containing equipment that will be disposed through a project in India being implemented by UNIDO

ID number as it is used in the former Yugoslav Republic of Macedonia


Open drain tap


Sampling at bottom valve with drip tray under drain

SAFETY PRECAUTIONS

While conducting the identification (inventory and sampling), one should take all precautionary measures not only for protection against exposure to PCBs, but also protection against electrical shock

4. Sample the equipment

Potential PCB-containing transformers

Not only the PCB content of transformers in use has to be checked, but also the contamination of transformers no longer in use or in reserve. Rigorous examination must also include spare oils and other equipment that could contain PCBs (capacitors, voltage regulators, circuit breakers, heat exchangers, oil cisterns and pipe systems, etc.). Often the meaning of abbreviations on transformer tags is misunderstood. For instance "ON" or "ONAN" applies to "Oil Natural" or "Oil Natural Air Natural" cooling. Only sampling and screening will prove if there is really no PCB contamination in the mineral oil.

Experience has shown that numerous transformers that were manufactured as PCB-free equipment actually do contain PCBs. In the 1970s, transformer manufacturers and oil suppliers often were not informed about the risks and the potential of cross contamination of PCBs by using identical cisterns, transport containers, pipe systems and fittings for mineral oil and PCBs. Therefore many new transformers were unintentionally contaminated by PCBs. However, often mineral oil filled transformers became contaminated by the user during refills or in the frame of maintenance activities. Therefore, all electrical devices not hermetically sealed need to be sampled even if they were recently manufactured, because unintentional contamination could have occurred.

Oil samples can be taken by using the drain tap which usually is at the bottom of the transformer.

If a transformer has been disconnected from power for over 72 hours, the sample should generally be taken from the bottom as PCBs sink to lower levels because of their higher density. Sometimes the gasket gets damaged when the drain tap is opened. It is therefore advisable to always have a spare gasket ready.

Alternatively, transformers can be sampled via the oil filling cap by using a hand pump (remember: a new hand pump must be used for each transformer). Oil samples from the expansion receptacle cannot however always be regarded as representative, because the oil does not circulate and thus it is not really mixed.

Usually, transformers are sampled when they are in use and thus when they are electrically alive. Relevant protective measures and safety regulations must be known and introduced at all times!

If the oil quality is to be tested, the following steps have to be considered:

› Sampling via drain tap: Drain off about 1 litre of oil first in order to clean the drain from particles which might have accumulated in that area,
› Amount of oil required: 0.2 to 1 litre (in case of oil quality analysis),
› Leave the oil for 24 hours, in order to allow particles and water to settle,
› Take sample from the upper third of the oil for the analysis using a pipette, and
› Return the drained oil back into the transformer (only if the oil filling cap is out of reach of the high voltage and oil is without heavy impurities, otherwise shut off the transformer before refilling oil)

Potential PCB-containing capacitors

If a capacitor cannot be sampled for technical reasons, it has to be regarded as potentially containing PCBs until the screening performed at the time of phase-out proves otherwise. In many cases, the capacitor manufacturer provided information about the type of dielectric liquid either with identification on the nameplate or with a separate tag confirming that the contents are harmful for the environment. This occurred, for example, where a former Soviet producer marked capacitors with a yellow triangle. Such capacitors do not need further investigation. They definitely contain PCBs and must be treated accordingly. After banning PCBs for use in electrical equipment, most of the capacitors were declared as PCB-free either on the nameplate or with a separate tag.

As capacitors are sealed entities, contamination after manufacture can be excluded. Considering the fact that after 1993 no PCB was produced, it can be assumed that capacitors manufactured after this date are PCB-free. In some cases, the manufacturer's technical instructions, the UNEP "Guidelines for the Identification of PCBs and Materials Containing PCBs", or a capacitor catalogue can be used to determine whether or not a capacitor contains PCBs. A copy of the catalogue published by the Australian and New Zealand Environment and Conservation Council (ANZECC) can be found on the Internet (http://www.environment.gov.au/settlements/publications/chemicals/scheduled-waste/pubs/pcbid.pdf).

Another very useful tool for the identification of capacitors with missing nameplates is comparing their pictures with pictures from a database. Therefore, it is recommended to take pictures of the equipment whenever possible and record them in a PCB database.

Capacitors that bear no information about the dielectric fluid and were manufactured before 1993 should be sampled and analyzed. Since capacitors are built into hermetically closed containers and there is no direct access to the cooling liquid, it is not possible to take samples for analysis without destroying the casing of the equipment. Thus only phased-out capacitors can undergo this procedure. Capacitors still in service and manufactured before 1993 with missing information about the dielectric liquid have to be labelled as PCB-suspect equipment. In the event that no data is available, it is best to label these with a yellow "Suspect" label and take a sample at the end of their service life before 2025.

Power capacitors are built into hermetically closed containers and there is no direct access to the cooling liquid.

If a designation is missing and relevant information from the manufacturer is not available, the only way to test the dielectric liquid is to drill a hole in the casing at the top or cut the isolator and retrieve an oil sample. This can be done by using a pipette (use only once). After this exercise, the capacitor is unusable and, as it is now damaged, it must be stored in appropriate containers (e.g. in an UN-approved steel drum). Therefore, it is advisable to only sample capacitors that are already out of service. If there is a series of the same capacitors, it is usually sufficient to sample only two devices out of the series.

It is recognized that testing should be preferred to simple statistical analyses and that access to laboratory testing facilities is required. In this context, the regional use of existing and approved laboratory services is useful as each country may not be able to acquire its laboratory facilities.

5. Screen the samples

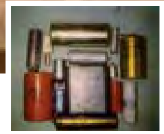
PCB analysis can be divided into two categories: specific and non-specific methods.

Specific methods include gas chromatography with electron capture detection (GC ECD) and mass spectrometry (MS), which analyze for particular PCB molecules. In general, PCB-specific methods are more accurate but they are more expensive, take longer to run, qualified staff is needed, and they usually cannot be used on site.

Non-specific methods identify classes of compounds such as chlorinated hydrocarbons, to which PCBs belong. These non-specific methods include preliminary PCB field screening tests like CLOR-N-OIL and CLOR-N-SOIL test kits, as well as the L2000 DX field analyzer, density tests and the Beilstein method.

Because of the chlorine content, PCB oils generally have high densities. Whereas mineral oil is usually lighter than water, PCBs may have a specific gravity of up to 1.5. Therefore PCB oil will sink to the bottom of a container when poured into water while mineral oil will float to the top.

Pyranol capacitor nametag: PCB containing


Small PCB capacitors should be considered


L2000 DX Analyzer training in Morocco

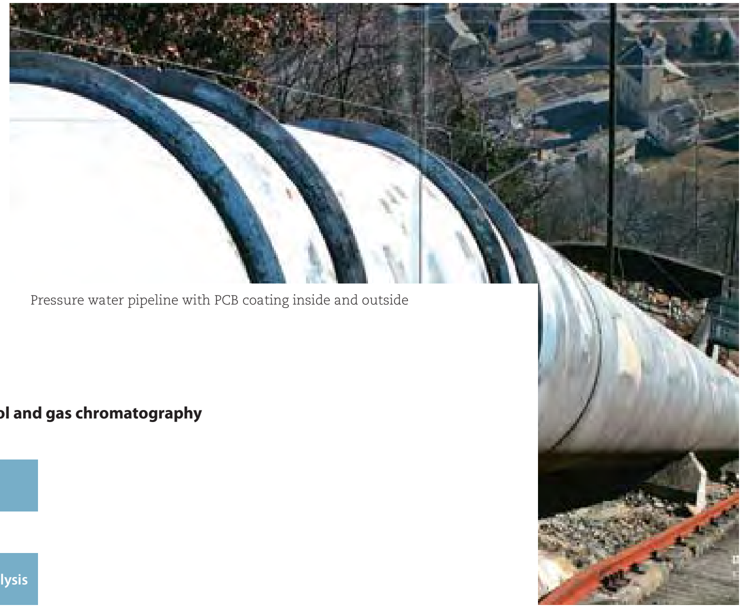
(cont. on page 56...)

Density test with transformer oil and water

Result of oil screening using a CLOR-N-OIL kit

Use of a test kit in the field in Swaziland

L2000 DX Analyzer in use in the former Yugoslav Republic of Macedonia



Pressure water pipeline with PCB coating inside and outside

It must be stressed that such tests only provide reliable information in case of pure or highly contaminated PCB oil and even considering financial restrictions, such tests cannot be recommended for professional inventory taking.

There are also immunoassay rapid tests on the market as tools for measuring PCBs, mainly in soil and water. Such methods apply the principles of enzyme linked immunosorbant assay to determine PCB concentration. The colour change is measured using a spectrophotometer and compared to a three-point calibration curve for quantification.

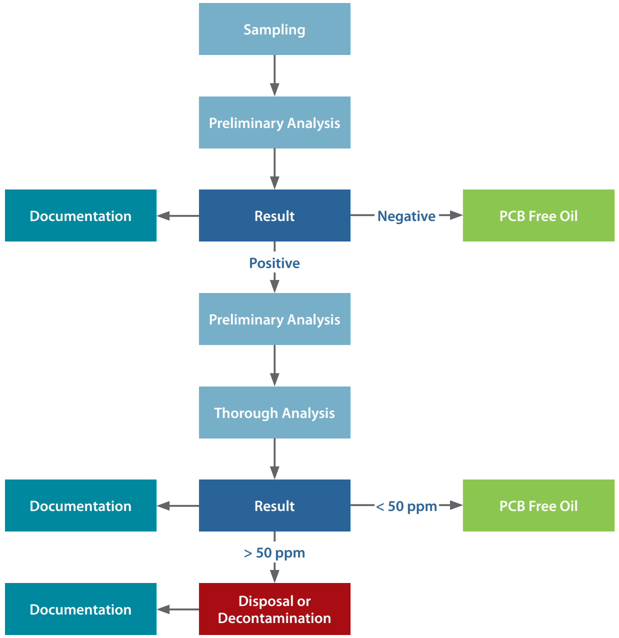
Faced with the prospect of taking an inventory for the PCB content of millions of electrical equipment in the USA in a very short time frame in the early eighties, the Electric Power Research Institute (EPRI) started a research programme to develop a field test kit that would help utilities solve this problem. The test would have to be easy enough to be used by workers in the field who were not necessarily chemists or engineers. It would have to be accurate enough to stand up to scrutiny by regulatory agencies, and rival a laboratory method in accuracy. It would further have to be robust enough to work in a mineral oil matrix and handle contamination by breakdown products and other contaminants that may be present in the oil.

Eventually a test kit was developed and registered under the trademark CLOR-N-Oil 50. This test was first introduced to the US market in 1983 and has been used extensively worldwide to reduce the cost of testing electrical equipment. Some major utilities estimated that the cost savings based on the distribution of PCBs in their system was between USD 1.5 and 3.7 million per 100,000 transformers tested. The test kits allow owners to "screen out" equipment as non-PCB containing equipment, without need for detailed and costly laboratory analyses. In 1989, an additional electrochemical screening method under the trade name L2000DX Chloride Analyzer was invented. This system also uses metallic sodium to convert the organic chlorine to chloride and uses a chloride specific electrode to quantify the chlorine content of the extract. Using a conversion factor, the maximum concentration of suspected PCBs can be calculated from the total halogen result. Using carefully controlled, pre-measured reagents, this method is considered comparable in results to those of GC. Used by a trained operator, its precision and accuracy rivals that of GC. Beside utilities and national PCB inventory teams, the L2000 has been used extensively by remediation companies for analysis of mineral oil dielectric fluid, soils and wipe samples when cleaning contaminated sites.

In view of future investigations into partially open and open PCB systems as part of national PCB inventories, an appropriate analysis method will be necessary.

Unfortunately, the existing test kits do not cater to these matrices. The presentation of any new analytical method should be carefully verified before being put into full operation.

A screening process using a screening tool and gas chromatography



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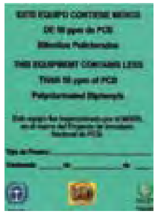


Label for PCB free devices from Guatemala

Label for PCB suspect devices from Morocco

Label for PCB containing devices from Moldova

An appropriate database enables easy access to information, tracking of identified devices and PCB stocks

6. Verify the results in the laboratory

Although considerable analytical costs and time are saved by using rapid screening tests, it is always useful to consider that these methods only screen the presence of chlorine in the samples. As a result, other chlorinated compounds, which can be part of the sample, could cause false positive results because the analysis method assumes all chlorinated compounds are PCBs. False negative results are not possible. If there is no chlorine present, PCBs cannot be present either. Thus if a screening test shows a negative result (PCB < 50 ppm) it must be true, so there is no need of verification by another method.

If a CLOR-N-Oil test kit or the L2000 DX analyzer screening tests shows positive screening result > 50 ppm, verification by gas chromatography is recommended. In this case, the sample for gas chromatography analysis is to be kept and forwarded to the appropriate laboratory (do not take a new sample, it must remain comparable). If results of a GC analysis show a significantly lower result than the screening tests, there is no reason to be alarmed. The tests are standardized for Aroclor 1242 with chlorine content of 42 %. Analyses with higher chlorinated PCB samples (e.g. Aroclor 1260 with chlorine content of 60 %) consequently show a higher result than the true PCB content. Thus the screening tests are always on the safe side.

Although false positive results obtained by the screening tests can cause unnecessary secondary testing, non-specific methods can be very economical when used on samples such as transformer oil, in which few sources of chlorine other than PCB exist. Used crankcase and cutting oils however always contain some chlorinated paraffin and almost every non-specific test produces false positive results. More expensive laboratory analysis is advised when testing for PCBs in these chlorine-containing oils.

7. Label the equipment

Once the PCB content has been determined, the PCB-containing or contaminated equipment must be labelled appropriately. This is an issue that frequently occurs in many countries where inventories have already been taken. There are many examples of good and bad labels. Preferences might differ but basically it seems favourable to use labels in bright colours for easy recognition. The following examples from three different regions demonstrate good labels.

Appropriate labels guarantee easy recognition whether or not the equipment contains PCBs. In case of accidents, these labels ensure that the hazards can be assessed at first glance from the colour of the label. Not too much text should be written; a brief explanation of the content and a contact address are sufficient. A 24-hours emergency phone number should be added as unfortunately incidents seldom follow office hours.

8. Develop a database

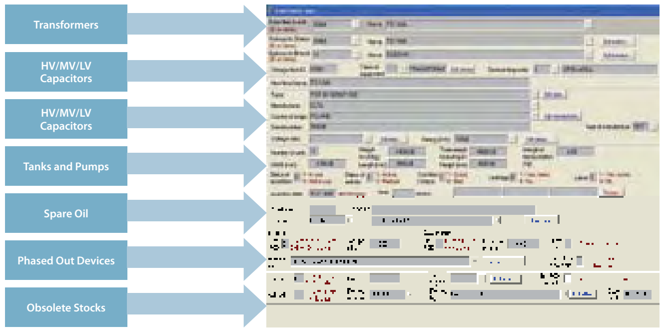
As previously mentioned, for sustainable inventories, there is need to establish professional databases. Excel sheets may be suitable for pilot projects and preliminary inventories but these are certainly not sufficient for sustainable inventories. The data from the inventory forms, including information on PCB containing equipment, its condition, location, owners, as well as pictures, have to be recorded in a database, which preferably is accessible to regional authorities and members of a steering committee. Although these stakeholders should be able to read the data, entering, recording and updating data should be the responsibility of only one assigned body.

Databases are ideal tools to set priorities, to assess risks and to prepare management plans and budgets. Databases enable the authorities to control the location and nature of the PCB equipment, as well as the success of all related activities. Databases facilitate the preparation of different reports using different parameters including the periodic reporting to the Conference of the Parties of the Stockholm Convention. In the future, these databases should ideally be used to track the lifecycle of PCBs.

9. Adopt an appropriate legal framework

Based on the results obtained through the inventory process, an appropriate legal framework, mainly legislation or regulation, can be adopted if needed to address issues identified during this process. Participation of different stakeholders in the identification process usually provides significant input and direction for the development of legislative and regulatory measures. Based on the evaluations and estimations regarding the scale of the problem with PCBs, the measures adopted will reflect the real situation regarding the national PCB problem. Provisions related to the PCB management can also be designed so as to be achievable for relevant stakeholders. If measures are adopted too early, the requirements prescribed may be difficult to implement and result in poor compliance with the measures.

Possible sources of closed systems – all to be recorded in an appropriate PCB database



10. Update the database

Once the PCB equipment has been identified and recorded in a database, this database needs to be continuously maintained and updated. As soon as a piece of equipment has been treated or eliminated in an environmentally sound manner, the status of this equipment in the database must be updated. The same applies if a PCB-free transformer is – despite all efforts to eliminate PCBs - accidentally filled with PCB contaminated oil. The tracking of all related electrical devices and all PCB containing wastes is essential in order to achieve the 2028 goals of the Stockholm Convention for implementing the environmentally sound management of PCBs.

11. Final remarks

Tremendous efforts have been made and huge resources allocated worldwide to gain control of the PCB problem. Initial actions were taken from the late 1970s and 1980s to stop PCB production and the manufacture of materials containing PCBs, long before the activities and efforts of the Stockholm Convention started. Yet considerable numbers of PCB devices and materials are still in use today, 40 years after the first efforts to address the PCB problem. Nevertheless, we should not shy away from the extensive work ahead. We shall not wait for legislative or regulatory actions, but rather be pro-active and act on a voluntary basis in order to prevent unnecessary cross contamination and therefore additional cost implications. We shall respect the problem; anticipate possible implications; share information - specifically negative lessons learned - and act appropriately in order to protect human health and the environment.

Assessing the nature and extent of the PCB problem in a country is the first step towards environmentally sound management and a PCB-free world. Such knowledge will help to set country-specific priorities and to choose country-tailored elimination solutions. It is our duty to do our tasks properly and to recognize potential dangers and problems before they occur. The latest environmental disaster in the Gulf of Mexico shows clearly that anticipation of possible damages and problems as well as far-sighted and sensible action could have spared the environment and also humans from the harmful effects being witnessed in that disaster.

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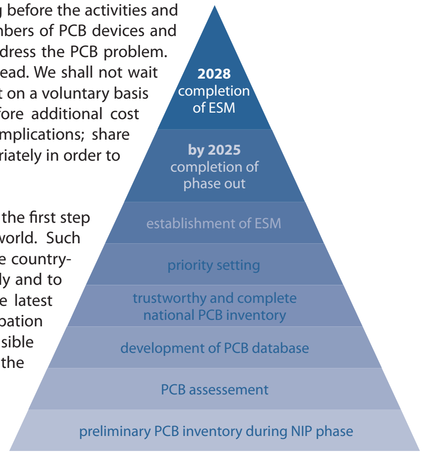

Pyramid of activities from PCB inventory to elimination

50

The concentration in parts per million (50ppm or 50mg/kg) of PCBs above which oil is considered contaminated with PCBs. For the reverse, this concentration is also then the 'low POPs content' below which oil contaminated with PCBs is not required for disposal