GUIDELINES FOR ENVIRONMENTALLY SOUND MANAGEMENT OF PCBS IN THE MEDITERRANEAN

UNEP

MAP

40 Years TOGETHER FOR A SUSTAINABLE MEDITERRANEAN

Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem

MedPartnership

Together for the Mediterranean Sea

GEF UNEP MAP

GUIDELINES FOR ENVIRONMENTALLY SOUND MANAGEMENT OF PCBs IN THE MEDITERRANEAN

UNEP

MAP

40 Years
TOGETHER FOR A SUSTAINABLE MEDITERRANEAN

Legal notice

The designations employed and the presentation of the material in this document do not imply the expression of any opinion whatsoever on the part of UNEP/MAP Coordinating Unit concerning the legal status of any State, Territory, city or area, or if its authorities, or concerning the delimitation of their frontiers or boundaries.

ISBN: 978-92-807-3521-5

These Guidelines have been commissioned by the marine pollution assessment and control unit (MED POL) of the Mediterranean Action Plan (UNEP/MAP) to the Regional Activity Centre for Sustainable Consumption and Production (SCP/RAC) under the MedPartnership Project.

Supervision: SCP/RAC

Technical contents: PM&E sustainability consulting: www.pmecon.com and INESCOP: www.inescop.es

PREFACE

This technical guide is focused on different aspects of PCB life cycle environmentally sound management (ESM), including inventory and monitoring until their final phasing out and disposal and its final objective is to provide the Mediterranean countries with information in order to establish a proper management system to prevent human health and environmental hazard.

It has been developed by UNEP/MAP MED POL Programme under the MedPartnership project[1] and in the framework of MAP Programme of Work 2014-2015.

Polychlorinated Biphenyls (PCBs) are among the Persistent Organic Pollutants (POPs) identified by the international community for immediate international action, along with the pesticide DDT, highly toxic Dioxins and Furans (unintentionally formed by-products as a result of incomplete combustion or chemical reactions) and other substances. The Stockholm Convention on Persistent Organic Pollutants (POPs) aims for the worldwide elimination of these substances.

PCBs have serious health and environmental effects, which can include carcinogenicity, reproductive impairment, immune system changes, and effects on wildlife causing a loss of biological diversity. The existing PCBs and all equipment contaminated with PCBs have to be eliminated in an environmentally sound manner without producing hazards for humans or the environment by 2028. Other global and regional conventions regulate the management of dangerous chemicals and hazardous wastes addressing PCB such as the Basel Convention, as well as the Rotterdam Convention. In addition the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its related Protocols (Land-based Sources and Activities Protocol, and the Hazardous Waste Protocol) also addresses the PCB phase out and disposal.

This technical guide provides background information on data collection, identification, sampling and monitoring of PCB containing equipment and describes PCB management of closed applications. It also explains maintenance of equipment containing PCB focusing on safety, emergency actions as well as phase out, packing and temporary storage. Finally it refers to international and national regulations for the transport of hazardous goods, as well as pretreatment, treatment and disposal of PCBs.

The guide was reviewed and agreed at a Regional Expert meeting, with experts nominated by the Contracting Parties, which was held from 7-9 April 2015 in Istanbul, Turkey and approved as appropriate by the MED POL focal point meeting. It is published online in English and French to serve as a technical guidance for the Mediterranean countries in implementing the relevant priority actions of the National Action Plans adopted in the framework of Article 5 and 15 of the LBS Protocol of the Barcelona Convention and its Strategic Action Programme SAP-MED.

1. The Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership) is a collective effort of leading organizations (regional, international, nongovernmental, etc.) and countries sharing the Mediterranean Sea towards the protection of the marine and coastal environment of the Mediterranean. The MedPartnership is being led by United Nations Environment Programme (UNEP) Mediterranean Action Plan (MAP) and the World Bank and is financially supported by the Global Environment Facility (GEF), and other donors, including the European Union (EU) and all participating countries.

TABLE OF CONTENTS

Abbreviations and Definition of Terms

AC Alternating Current

ADR European agreement on the international road transport for hazardous goods

Askarel Trade name of PCB cooling fluid (USA, Monsanto)

BAT Best Available Technique

BC Basel Convention on the trans-boundary movement of hazardous wastes and their disposal

BCD Base catalysed decomposition

BEP Best Environmental Practice

BRS Basel, Rotterdam, Stockholm Convention (Secretariat)

CaO Calcium oxide

Capacitor Equipment or unit to supply lagging kilovars for power factor correction of an electric system; some capacitors were manufactured with PCB as cooling fluid

Capacitor Bank (General)
Practically there are three different ways of power factor (PF) correction:
Capacitors for «individual» PF-correction; the capacitor is directly connected to the terminals of an equipment (motors, welding machine etc.) producing the «lagging kilovars»

Capacitor Bank (LV)
Capacitors for «group» PF-correction; the capacitor(s) is (are) connected to the LV-busbar of a transformer station, which feeds a number of consumers with individual motors, welding machines etc.

Capacitor Bank (MV)
Capacitors for «central» PF-correction; Large capacitor installation connected to the Middle- or High Voltage busbars of a substation where many individual electrical appliances (motors etc.) of various size operate at different times and periods.

CHD Catalytic hydrodechlorination

Closed Systems
Capacitors and transformers, where the PCB itself is in completely closed containers; PCBs rarely emit from closed systems (in good condition)

Congener Depending on the number and position of the chlorine atoms in the Biphenyl molecule, 209 isomers and homologue Chlorine Biphenyls are theoretically possible. A single compound from this group is called PCB congener.

Container 20’
Internationally used expression for Transport or Storage Containers

with the Standard size of 2 x 2 x6 meters (40' Container – 2 x 2 x 12 meters)

Container Box
There are various types of 20' and 40' Containers available, the most common is the Box Container with a front door, from an open top Container the roof can be removed for loading and off-loading activities (e.g. ideal for transformers)

Cooling Fluid
Dielectric fluid

COP Conference of the Parties
DC Direct Current
DDT Dichlorodiphenyltrichloroethane
DE Destruction efficiency
DRE Destruction and removal efficiency
e.g. Exempli gratia / for example
ESM Environmentally Sound Management
ETI Environmental Technology International Ltd. / Switzerland
EU European Union
FAO Food and Agriculture Organization of the United Nations
GC Gas chromatography; Procedure for the determination of evaporating substances
GEF (GEF) The Global Environment Facility is an international financial entity with 177 countries as members
GHS Globally harmonized system of classification and labelling of chemicals
GPCR Gas-phase chemical reduction
GTO Gate turn-off thyristor
HV High voltage
IATA DGR IATA regulations on the transport of dangerous goods / transport by air
IBC Intermediate Bulk Container

ID (number)
Identification (number)

IGBT Insulated-gate bipolar transistor
IMDG International maritime dangerous goods code / transport by sea
ISO International Organization for Standardization
kV Kilovolts
kVA Kilovolt ampere
kVAR Kilovolt ampere reactive
kW Kilowatt
LBS Land based sources and activities Protocol
LV Low voltage (230/400 V)

MAP MEDPOL
Programme for the Assessment and Control of Marine Pollution in the Mediterranean

µg Microgram
mg/kg Milligram per kilogram
MS Mass spectrometry
MV Medium voltage (Normally in the range between 11 and 66kV)
MVA Megavolt ampere
ng Nanogram (1000 ng = 1 µg)
NGO Non-governmental organization

Open Systems
Applications where PCB is consumed during its use or not disposed of properly after its use or after the use of the products that contain PCB;
Open systems emit PCB directly in the environment (e.g. softeners in PVC, neoprene and other rubbers containing chloride)

PBB Polybrominated Biphenyls
PCB Polychlorinated Biphenyls
PCDD Dibenzo-p-dioxins or dioxin; Highly toxic by-product of PCB
PCDF Dibenzofurans or furan; Highly toxic by-product of PCB
PCT Polychlorinated Triphenyls
PE Polyethylene
PE-HD High-density polyethylene
PE-LD Low-density polyethylene
PEN PCB Elimination Network of UNEP Chemicals
Persistent Very slightly degradable in the environment
PIC Prior Informed Consent
POP Persistent Organic Pollutants
PPE Personal Protective Equipment
ppb Parts per billion
ppm Parts per million (mg/kg)

Primary source
A product to which PCB was added voluntarily to influence the product's characteristics (e.g. cooling fluids for transformers like Sovol, Sovtol, Askarel, Pyralene, Clophen, etc.); Such products emit PCB continuously

RC Rotterdam Convention on the Prior Informed Consent Procedure (PIC) for certain hazardous chemicals and pesticides in international trade
RID Regulation for the international transport of hazardous goods / transport by rail
SAP-MED Strategic Action Programme to address pollution from land-based activities in the Mediterranean Region
SBC Secretariat of Basel Convention
SC Stockholm Convention Persistent Organic Pollutants (POPs)
SCWO Supercritical water oxidation
Secondary source A product that originally was free of PCB, but later contaminated by PCB emitting from primary sources (e.g. by emission from primary sources or use of contaminated pumps, hoses, etc.) Such products also emit PCB
SNV Swiss Association for Standardization
SPCC Spill Prevention, Control and Countermeasure
TDI Tolerable daily intake
TEQ Toxic equivalency factor

Transformer
Equipment used to increase or reduce voltage; PCB containing transformers are usually installed

in sites or buildings where electricity is distributed.

TTCB Tri-tetrachlorobenzenes

UN-approved Equipment that fulfils the specific United Nations testing procedures

UNDP United Nations Development Programme

UNEP United Nations Environment Programme

UNIDO United Nations Industrial Development Organization

UNITAR United Nations Institute for Training and Research

US EPA United States Environmental Protection Agency

WHO World Health Organisation

INTRODUCTION

1.1. Polychlorinated Biphenyls (PCBs)

Persistent Organic Pollutants (POPs) have been identified by the international community for immediate international action by means of the Stockholm Convention. The pesticide DDT, highly toxic Dioxins and Furans (unintentionally formed by-products as a result of incomplete combustion or chemical reactions) as well as PCBs count among the POPs.

PCBs have serious health and environmental effects, which can include carcinogenicity, reproductive impairment, immune system changes, and effects on wildlife causing a loss of bio¬logical diversity (Carpenter 2006, Hotchkiss et al. 2008, Wirgin et al. 2011). PCBs bio-accumulate in the fatty tissue of humans and other living organisms. The chemical is transported over long distances to regions where it has never been used or produced before. This process of evaporation, movement with the air streams, condensation and deposition on the ground is known as the "grasshopper effect".

PCB production started in 1929. PCBs were manufactured by a number of companies in many industrialised countries, and maximum production was reached in the late 1960s. After 1983 production was stopped in most countries, except for some Eastern European countries and Russia, where manufacture ceased between 1987 and 1993.

PCBs were mostly used in closed applications for example as cooling and isolating agents in transformers and capacitors, in heat transfer systems and hydraulic systems, in particular in mining equipment. PCBs mixtures were, however, also widely used in open and partially open applications, for example in caulks/sealants, paints, anti-corrosion coatings, surface coatings, cables and cable sheaths, small capacitors, etc.

From the technical point of view, the characteristics of PCBs were quite advantageous, thus they found a wide range of applications as mentioned above.

The Stockholm Convention on Persistent Organic Pollutants (POPs) counts PCBs among the substances targeted for worldwide elimination. The existing PCBs and all equipment contaminated with PCBs have to be eliminated in an environmentally sound manner without producing hazards for humans or the environment by 2028. PCB treatment or disposal technology must comply with the highest safety and environmental standards and must be capable of reducing the PCB contamination level of those pieces of equipment suitable for re-classification below the legally permitted level of 50 ppm as well as assure that the PCB level remains below that limit.

Other global and regional conventions regulate the management of dangerous chemicals and hazardous wastes addressing PCB such as the Basel Convention, as well as the Rotterdam Convention. In addition the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its related Protocols (Land-based Sources and Activities Protocol, and the Hazardous Waste Protocol) also addresses the PCB phase out and disposal.

1.2 Basel Convention

In 1989, the Basel Convention was adopted to improve monitoring of the transboundary movements of hazardous wastes.

The Basel Convention has the following key objectives:

- To reduce transboundary movements of hazardous wastes to a minimum consistent with their environmentally sound management
- To dispose of hazardous wastes as closely as possible to their source of generation
- To minimize the generation of hazardous wastes in terms of quantity and hazardousness
- Prohibition of an export of hazardous waste to developing countries that do not have suitable disposal technologies

The Basel Convention has set up a very strict operational control system based on the prior written notification procedure. The procedure for the notification of transboundary movements of hazardous wastes or other wastes can take place only upon prior written notification to the competent authorities of states of export, import and transit (if appropriate) and upon consent from these authorities permitting the transboundary movement of waste. Any transboundary movement of hazardous wastes or other wastes carried out in contravention of notification system is considered illegal traffic.

1.3 Stockholm Convention

This Convention regulates the prohibition of - so far - 23 toxic chemicals called the POPs (Persistent Organic Pollutants).

The text of the Stockholm Convention on Persistent Organic Pollutants was adopted on 22 May 2001 and entered into force on 17 May 2004; 90 days after the 50th member country had ratified it.

The initial twelve POPs are Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Hexachloro-benzene, Mirex, Toxaphene, Polychlorinated Biphenyls (PCBs) as well as Dioxins and Furans (unintentionally formed by-products as a result of incomplete combustion or chemical reactions).

At its fourth meeting held from 4 to 8 May 2009, the Conference of the Parties (COP) adopted amendments to Annexes A (elimination), B (restriction) and C (unintentional production) of the Stockholm Convention to list nine additional chemicals as persistent organic pollutants: Chlordecone, Hexabromobiphenyl, Lindane, Alpha Hexachlorocyclohexane and Beta Hexachlorocyclohexane, Tetrabromodiphenyl ether and Pentabromodiphenyl ether, Hexabromodiphenyl ether and Heptabromodiphenyl ether, Perfluorooctane Sulfonic Acid, its salts and Perfluorooctane Sulfonyl Fluoride, Pentachlorobenzene. These amendments entered into force on 26 August 2010.

During the fifth meeting of the Conference of the Parties in April 2011, the Parties agreed to list Endosulfan in Annex A to the Convention, with specific exemptions. One year later, Endosulfan became the 22nd POP.

Finally, at its sixth meeting held from 28 April to 10 May 2013, the Conference of the Parties adopted an amendment to Annex A to list Hexabromocyclododecane with specific exemptions (decision SC-6/13). On 26 November 2014, one year after notification, the amendment listing HBCD in Annex A to the Stockholm Convention entered into force for most parties.

The contracted parties to the Stockholm Convention must take the following measures:

- Production, use, import, and export of the 23 most dangerous POPs shall be eliminated or restricted. For DDT a special regulation has been stipulated, as this product is used in developing countries to fight malaria
- When constructing new plants/ installations measures shall be taken to minimize a possible production of POPs
- Stockpiles and wastes that are contaminated with POPs shall be recorded in an inventory and disposed of in an environmentally sound manner
- The use of devices containing PCB is still permitted until 2025, under the condition that certain safety precautions and conditions are fulfilled
- By the year 2028, however, all PCB equipment shall be disposed of in an environmentally sound manner

1.3.1 PCBs Elimination Network (PEN)

The PCBs Elimination Network (PEN) was launched at the simultaneous extraordinary meetings of the Conferences of the Parties to the Basel, Rotterdam and Stockholm Conventions in Bali on 22 February 2010. The PEN has been established as an arrangement for information exchange on the promotion of the cost-effective completion of the environmentally sound management (ESM) of liquids and equipment containing or contaminated with PCBs. The PEN is designed as an equal partnership for stakeholders from different sectors with an interest in the ESM of PCBs to interact within a voluntary framework to undertake the following:

- Promote ESM of PCBs and its equipment
- Foster cooperation
- Promote technical assistance and technology-transfer
- Provide and facilitate information exchange
- Raise awareness
- Encourage development and adoption of environmentally sound techniques and practices to eliminate PCBs
- Establish linkages between stakeholders

The PEN is an arrangement built on the platform of the clearinghouse mechanism, providing support to developing country Parties and Parties with economies in transition to reach the goals of the Stockholm Convention in relation to PCBs. The PEN shall implement its work on information exchange being mindful of the obligations of the Basel Convention on the transboundary movement of hazardous waste and its disposal and of the Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade. The application form for becoming a member of the PCBs Elimination Network (PEN) is attached in Annex 12.200.

1.3.2 Handling of PCBs Regulated in the Stockholm Convention

It is forbidden:

- To produce, import and trade PCBs
- To re-use and process PCB waste
- To re-fill PCB equipment

Legal and physical entities that possess PCBs, used PCBs and PCB equipment are obliged to report the quantity, origin, nature and content of PCBs, used PCBs and PCB containing/contaminated equipment to the responsible government agency/body for the professional activities in the field of environment not later than one year after the Convention enters into force. Entities are obliged to proper label the equipment. Legal and physical entities handling PCBs, used PCBs and PCB equipment are obliged to keep records in accordance with the convention.

1.4 Rotterdam Convention (PIC Convention)

Toxic pesticides and other hazardous chemicals kill or seriously sicken thousands of people every year. They also poison the natural environment and damage many wild animal species. Governments started to address this problem in the 1980s by establishing a voluntary Prior Informed Consent procedure. PIC required exporters trading in a list of hazardous substances to obtain the prior informed consent of importers before proceeding with the trade.

In 1998, governments decided to strengthen the procedure by adopting the Rotterdam Convention, which makes PIC legally binding. The Convention establishes a first line of defence by giving importing countries the tools and information they need to identify potential hazards and exclude chemicals they cannot manage safely. If a country agrees to import chemicals, the Convention promotes their safe use through labelling standards, technical assistance, and other forms of support. It also ensures that exporters comply with the requirements. The Rotterdam Convention entered into force on 24 February 2004. The contracting parties take measures to:

- Establish an official notification procedure i.e. to inform the importing country that an export of a chemical figuring on the PIC list will take place before the first shipment
- Inform the importing country that an export of a chemical that is banned or severely restricted for use within its territory will take place before the first shipment
- Inform other countries of each national ban or severe restriction of a chemical

1.5 UNEP/MAP-Barcelona Convention and its Protocols

The UNEP/MAP-Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean was adopted in 1995 thus amending the Barcelona Convention on the protection of the Mediterranean sea against pollution adopted in 1976 by the Mediterranean coastal states and European Union. The Barcelona Convention operates in the framework of the Mediterranean Action Plan adopted and amended respectively in 1975 and 1995. The Secretariat is provided by UNEP through the UNEP/MAP Coordinating Unit located in Athens, Greece.

The Barcelona Convention is associated by seven important protocols out of which two address different aspects of POPs management namely the Land based sources and activities Protocol, 1996 (LBS Protocol) and the Protocol on the trans-boundary movement of hazardous waste in the Mediterranean, 1996.

The LBS Protocol provides for the contracting parties to take legally binding measures to phase out a number of substances including PCB and their stocks in synergy with the work and commitments taken under the Stockholm Convention.

UNEP/MAP- Barcelona Convention is supporting the Contracting Parties to implement the SAP-MED (Strategic Action Programme to address pollution from land-based activities in the Mediterranean Region) and associated National Action Plans adopted in accordance with Land Based Sources and Activities Protocol of the Barcelona Convention which provide for a number of regional targets by 2025 related to hazardous waste and POPs ESM including phasing out and disposal.

The Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem (MedPartnership) is a collective effort of leading environmental institutions and organizations together with countries sharing the Mediterranean Sea to address the main environmental challenges that Mediterranean marine and coastal ecosystems face. The project is led by UNEP/MAP and is financially supported by the Global Environment Facility (GEF) and other donors, including the European Commission and all participating countries. Within the framework of the project, UNEP/MAP, through its MEDPOL programme, aims to support countries in the implementation of the SAP-MED. The project is supporting the EMS disposal of up to 870 tons PCB as well as undertaking important capacity building activities in four Mediterranean countries, including the preparation of EMS Guidelines for PCB.

The proposed Guide on PCB ESM is prepared with the technical support of Urs K. Wagner (ETI Umwelttechnik AG, Chur/Switzerland).

DATA COLLECTION, IDENTIFICATION, SAMPLING AND MONITORING

2.1 Data collection and Inventory

The inventory is the initial stage in the management of PCB contaminated equipment and it should be generated in the most ecological way. Implementing the following general activities will support a reliable PCB data collection:

- Assessment of the national PCB situation
- Legal assessment of national regulations
- Identification of possible stakeholders
- Awareness raising workshops for possible stakeholders, capacity building
- Preliminary inventory
- Public information
- Adaptation of national regulations
- Information of the identified stakeholders
- Detailed inventory (physical inspection, sampling, analysis, database)
- Infrastructure (handling, transport, interim storage, disposal)

The aim of the inventory is to identify, quantify and keep records of the equipment and the materials prone to containing or being contaminated with PCBs. These bits of information are indispensable when preparing a plan for PCB management, which should encompass the entire cycle of these products, as follows:

- Usage
- Management
- Storage
- Decontamination
- Elimination

Table 1: Potential holders of PCB

Electric Utilities	Maintenance Companies
Industrial Facilities	Hospitals
Railroad Systems	Research Laboratories
Mining Industry	Manufacturing Plants
Army Installations	Waste Water Discharge Facilities
Residential or Commercial Buildings	Car Service Stations
Holiday Resorts / Hotels	Small/Medium sized Co.
School Buildings	Airports
Cold Storage Depots	Wood Processing Co.
Suppliers	Disposal & Recycling Companies

The sites with possibly PCB containing equipment shall be inspected by field teams or engineers of the authorised body in the field of environmental protection. During the inspection the particulars given in the questionnaires shall be checked and further data regarding the particular type of PCB equipment or PCB waste collected and recorded, for example *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.

The following data need to be collected and recorded when compiling the PCB inventory:

In-service transformers

- kVA rating
- Brand name
- Fluid quantity
- Type of fluid (brand of the fluid)
- Location of transformer producer
- Number
- PCB concentration (not for refilled transformers)
- Year of manufacture
- Weight of the transformer
- Status/owner

Out of service transformer

- kVA rating (transformer capacity)
- Brand name
- Fluid quantity
- Location of the transformer producer
- Number

- PCB concentration (not for refilled transformers)
- Year of manufacture
- Weight of the transformer
- Status/owner

In-service capacitors

- kVAR rating
- Brand name
- Location of the capacitor producer
- Number
- Year of manufacture
- Weight of the capacitor
- Status/owner

Out of service capacitors

- kVAR rating
- Brand name
- Location of the capacitor producer
- Status/owner
- Number
- Year of manufacture
- Weight of the capacitor

Bulk storage tanks, drums and containers

- Type
- Location
- Weight
- Fluid quantity
- PCB concentration
- Status/owner

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 the 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 conclusion about PCB presence cannot be made based on the available data, then equipment has to be sampled. The data entry for status can include codes for leaking, stable, packed etc., which can be found at the transformer nameplate.

Not only the PCB content of transformers in use has to be checked, but also the contamination of devices out of use or in reserve. Rigorous examinations must include spare oils and other equipment that could contain PCBs (capacitors, voltage regulators[2], circuit breakers, heat exchangers, oil cisterns, pipe systems, etc.). Only equipment exceeding the capacity of one litre must be declared. All transformers have to be sampled even if they are of recent date of manufacture because a later unintended contamination of the transformer could have occurred (see also chapter 2.4). If a device cannot be sampled for technical reasons (e.g. capacitor), it has to be regarded as containing PCB until the sampling performed at the time of the phase out proves the opposite.

2.2. PCB Applications

Closed, partially open and open applications of PCBs are presented in the tables below.

Table 2: Closed Applications of PCBs

Insulation and/or cooling fluid in **transformers**
Dielectric fluid in **capacitors**
Hydraulic fluid in **lifting equipment, trucks** and **high pressure pumps** (mining industry especially)

Table 3: Partially Open Applications of PCBs

Vacuum pumps
Switches
Voltage regulators
Liquid filled electrical cables
Liquid filled circuit breakers
Heat transfer fluids
Hydraulic fluids

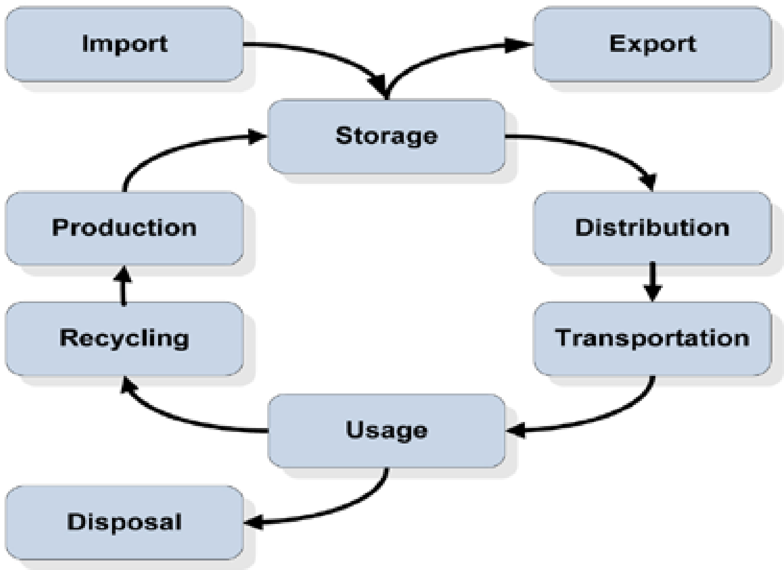
Table 4: Open Applications of PCBs

Caulks/sealants (buildings)
Paints and plaster
Anti-corrosion coatings (indoors and outdoors)
Surface coatings (e.g. floors)
Cables and cable sheaths
Sealed double glazing windows
Lubricating fluid in oils and grease; cutting oils
PCBs as flame retardant and impregnating agent (e.g. indoor wood sealing for panels and floor finishers)
Adhesives
Carbonless copy paper
Inks
etc.

2. Voltage regulators are devices similar to transformers and have an iron core and windings used to boost up the voltage in long overhead power lines (the American –English name for a voltage regulator is booster). A rectifier is a device to change Alternating Current (AC) to Direct Current (DC). In use are semiconductors as Thyristors, GTO's IGBT's to "rectify" the AC. These electronic devices do not contain PCB.

The Chemical lifecycle of POPs and specifically PCB shall always be considered.

Chart 1: Chemical lifecycle of PCBs



2.2 Periodic Examinations and Maintenance of PCB Containing Devices

Devices containing PCB are subject to regular periodic checks. These examinations mainly consist of checking the parameters from a technological and production aspect (e.g. technical characteristics, electric permeability of insulating materials, losses).

Due to possibility of contamination of the environment, additional inspections are needed with devices identified as PCB-containing. These inspections are mainly from the aspect of leakage of contaminating insulating oils. Thus, the following inspections should be added to the warrant for regular inspections (if not already envisaged from another aspect):

- Inspection of all sealing elements of the device

(the check consists of a visual inspection if some element leaks)

- Inspection whether any of the elements containing insulating oil is oxidized (corroded) (this check is performed visually, because devices containing insulating oil are painted regularly due to easier dissipation of heat)
- Inspection for deformations of the housing of the device (hermetically sealed capacitors often "puffed up")

If any of the above damages are confirmed, then a proposed intervention procedure follows:

- The bolts are re-tightened. If this does not stop the leakage, then a part of the insulating oil is drained "under the level of the edger" and the sealer is switched.
- The oxidized surface is cleaned from the oxide with a steel brush and sanding paper to reach metal shine. Afterwards, the spot is degreased with solvents, and the metal is checked for punctures and leakage with absorbing paper (filter paper or common paper handkerchief will also do the job). Even if there is no leakage, the spot is impregnated with means for neutralizing the iron oxide ("Antirost" or similar) and at the end are painted with basic and covering paint as the other part of the transformer. If even smallest leakage is noticed, the element (i.e. the radiator) must be demounted and welded, replaced if possible or the transformer should be taken to an industrial reparation. If the element is a condenser, it is discarded and replaced with a new one.
- The capacitor is discarded and replaced with a new one.

ADVICE:
ALL THESE INTERVENTIONS ARE TO BE PERFORMED BY SKILLED AND AUTHORISED SERVICE ONLY.

2.2.1 Sampling of Transformers, Capacitors and Construction Materials

It is advisable to prepare a sampling box that contains basic equipment for sampling activities. This ensures access to essential equipment immediately when required.

Picture 1: Inside view with possible equipment I

Picture 2: Consider also electric safety precautions

Normally glass bottles are used for liquid samples and glass or plastic containers for solids. However if a high PCB content is expected (e.g. in case of pure PCB) glass bottles must always be chosen, because PCB can diffuse through plastic containers.

Sampling containers must be absolutely clean. Whenever sampling containers are transported over long distances, demands on the glass quality (unbreakable) obviously increase.

Table 5: Minimum sample quantities and sampling containers

Method	Matrix	Quantity	Container
Clor-N-Oil	Oil	10 ml	➢ 20 ml glass vial (white lid)
Clor-N-Soil	Solids (e.g. soil, concrete dust, etc.)	10 g	➢ 60 ml glass vial (white lid) ➢ 250 ml PE-HD container (plastic, white with blue lid)
L 2000 DX	Oil	10 ml	➢ 20 ml glass vial (white lid) ➢ 30 ml glass bottle Hexavis (brown with black lid)
L 2000 DX	Solids (e.g. soil, concrete dust, etc.)	Minimum 10 g, if possible more	➢ 60 ml glass vial (white lid) ➢ 250 ml PE-HD container (plastic, white with blue lid)
GC (lab)	Oil	20 ml	➢ 20 ml to ½ litre bottles
GC (lab)	Solids (e.g. soil, concrete dust, etc.)	10 g	➢ 60 ml glass vial (white lid) ➢ 250 ml PE-HD container (plastic, white with blue lid)

When preparing the sampling box, the intended minimum number of samples has to be considered. This depends on the kind of PCB analysis and possible further analyses (e.g. oil quality in case of negative PCB result).

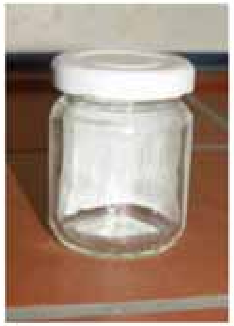
Please consider that the above-mentioned quantities are minimum figures. It is advisable to always take more sampling material e.g. to fill a 250 ml PE-HD container with soil. For drill samples minimum quantities are acceptable because of the often difficult sampling procedures.

To determine the quality of a transformer's cooling fluid at the same time, sample at least 500 ml of the oil. It should be filled in a 500 ml glass bottle (with blue lid). There are various manufacturers of quality glass bottles as e.g. Schott, Duran or Simax.

Picture 3:Glass vial

Picture 4:30 ml Glass bottle Hexavis

Picture 5: 500ml Glass bottle Duran



Picture 6: 60 ml Glass Vial

Picture 7: 250 ml PE-HD Cont.

Picture 8: 750 ml PE-HD Cont.

2.2.2 General Sampling Procedures
The main source of error is the sampling process itself. Therefore the following points must be particularly considered:

Risk of Cross Contamination
Contamination is easily spread from one sample to another. When using one-way material (e.g. Kleenex, pipettes, metal scoops, etc.) it must be ensured that a new product is used for every new sample. If this is not possible, the used equipment must always be cleaned before another sample is taken. If possible, solvents (e.g. technical acetone) should be used for cleaning purposes.

Confusion of Samples
In order to prevent a confusion of samples, it is crucial to clearly mark the sample containers immediately after the sample has been taken. The identical data must also be recorded in a sampling report. A label must be affixed to the sampling containers.

Picture 9: Taking all records of sampled electr. devices

Picture 10: Labelling BEFORE Sampling

Sampling Reports:
The sampling report must be filled in immediately. If it is completed at a later stage, important information could be lost or forgotten.
Sampling forms must be used to record the data required for evaluation and interpretation, for quality assurance and to ensure comparability with other assessment observation.

As opposed to laboratory procedures, no standard procedure for the performance of sampling can be given, since both the circumstances and the potential problems encountered are manifold. The ISO (ISO 2002c) recommends that quality assurance be performed according to the principles of the ISO 9000 standard (SNV 1999). An adequate standard of quality demands the application of quality assurance methods. Quality assurance involves strategies for the reduction of errors in sampling and sample treatment from the planning to the operational stage, by making the procedural steps readily comprehensible and retraceable (ISO 9000). Quality assurance also obliges those performing the sampling activities to uphold the necessary standards during their task and on all sites.

2.2.3 Sampling of Transformers
In order to prevent skin from getting into contact with PCBs, one-way protective gloves must be worn. Eyes must be protected against possible oil splashes by wearing goggles.

The sample 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 PCB sinks to the lower level because of its 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 (consider: a new hand pump must be used for each transformer). Oil samples from the expansion receptacle cannot always be regarded as representative, because the oil does not circulate and thus it is not really mixed.

Often, transformers are sampled when they are in use. Appropriate protective measures and safety regulations by responsible Electricians must be known and considered at any time!

If only the PCB content of the oil is analysed, 20 ml glass vials can be used provided analysis is performed on site. If the analysis is performed elsewhere and the samples have to be transported over long distances, 30 ml glass bottles should be used as sample containers because they are more robust. If a holder of a transformer also wants to have the quality of the oil tested, a 500 ml glass bottle should be used.

If a PCB inventory demands an analysis of the cooling fluid, the owner has the possibility to test the oil quality at the same time. This is dependent on the age and condition of the equipment. Such a preventive maintenance allows an assessment of the technical condition of the transformer and thus helps prevent possible damages/failures resulting from e.g. acidity or increased dampness.

Oil quality analyses must only be run after negative PCB result; otherwise the laboratory equipment will be contaminated with PCB.

The following steps must be followed when sampling a transformer:

- Place a drip tray under the drain tap,
- Label the sample bottle with the same serial number as on the inventory form,
- Drain off the required oil into the glass vial - quantity depending on screening/ analysis
- Carefully retighten the seal.
- Then affix a label on the transformer with the same serial number as on the inventory form   and the glass vial. The label usually contains the Identification number and Date of sampling

Step-by-step Sampling of a Transformer

Prepare sampling material and label the glass vial before sampling

Place drip tray under drain tap, wearing gloves and goggles

Open drain tap/valve (usually by local electrical technician)

Sample the oil (30-50ml for PCB screening, 1l if also oil quality is tested)

Affix sampling label on transformer (after cleaning the surface)

Record sample in sampling report, affix sampling label to report

Screen the oil sample by Clor-N-Oil or L2000 DX Analyzer

Collect and dispose of screening materials as hazardous wastes

When test results are available,re-label the tested transformer

If the **oil quality** shall also be tested, the following steps have to be considered:

- Sampling via drain tap: Drain off 1 to 2 litres of oil first in order to clean the drain from particles which might have accumulated in that area,
- Amount of oil required: 0.5 to 1 litres,
- 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 1 to 2 litres of oil back into the transformer (only if the oil filling cap is out of reach of the high voltage, otherwise shut off the transformer before refilling the drained oil)

All wastes must be disposed of in an environmentally sound manner – the disposal method always depends on the analysis result.

Remark: Sampling is also an opportunity to collect useful information for the database.

2.2.4 Sampling of Phased Out and Drained Transformers

Often transformers have already been phased out, temporarily stored and drained at the time a PCB inventory is compiled. In such cases, it needs to be decided on site, how the sampling shall be performed.

Even if a device has been drained, there should still be some oil present in the passive part of the transformer due to the leaching in the days and weeks after the draining. Depending on the size of the transformer, the leaching from the solid parts of the device (wood, insulation paper, etc.) can leave a few litres of oil at the bottom of the transformer. However, usually there is not enough oil to sample it via the drain tap, as the oil layer is deeper than the valve.

In such cases, the device needs to be sampled through an opening in the top. Stiff tubes (e.g. glass or PE) can be used to take a sample of the oil at the bottom of the transformer.

The PCB results obtained from drained transformers could be higher than the original contamination in the transformer. This is due to the leaching effect from the core and windings into only a limited volume of oil.

If there is no oil at all left in the device, solid materials from the active part of the transformer could be sampled and analyzed (wood or insulation paper). However, such analysis can only be performed in a laboratory by gas chromatography.

Due to practical reasons it might be advisable to label such drained transformers as PCB-contaminated and note it accordingly in the physical site inspection report (respectively inventory form) and leave it for future investigations.

Picture 11: Sampling of oil drums

Picture 12: Affix labels while sampling and later final one

2.2.5 Sampling of Capacitors

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

In many cases, the 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. Such capacitors do not need further investigation. They definitely contain PCBs and must be treated accordingly.

Picture 13: Identification of Capacitor Fluid

Picture 14: Tag Information on Capacitor

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 on the top or cut the isolator and retrieve an oil sample. This can be done by (e.g.) using a pipette (using only once).

After having opened the capacitor, it is damaged and unusable and thus must be stored in appropriate containers (e.g. in an UN-approved steel drum).

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 suspected equipment (see chapter 2.5).

If there is a series of the same capacitors, it is usually sufficient to sample only two devices out of the series. Preferably a mixed sample originating from the two capacitors with the lowest serial numbers should be analysed. Caution should be taken if the analysis reveals PCB, even if it is only a slight contamination. Such contamination could have been caused during the production e.g. when using the same pumps for mineral oil and PCB oil. In such cases, all capacitors of one series must be analytically tested.

Personal Protective Equipment (PPE)
The PPE for these activities consist of protective gloves and goggles. Respiratory protection is not necessary when taking single samples. If several samplings are taken within short intervals light respiratory protection is recommended.

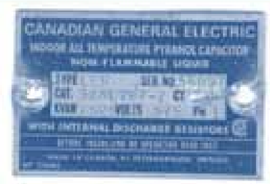
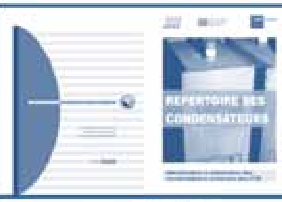
Sampling of Small Sized Capacitors
Usually capacitors of a smaller size do not contain PCB as a floating liquid in the casing, but rather as an impregnating agent of the insulation layers in the capacitor. It is therefore not possible to drill a hole in the casing and take an oil sample with a pipette.

Prepare the working place with an oil carpet and a tray (metal if available). The personal protective equipment comprises gloves, safety goggles and in case of poor ventilation a respiratory mask. Firstly, a circle has to be cut around the top end of the capacitor casing near the contacts using a small iron saw. Once the top has been lifted, it is usually possible to pull out the active part (caps don't have windings as such). With a tool remove about 1 cm3 of the insulation and conductor layers and place them in a 60 ml glass vial. The samples can then be prepared in the laboratory and analysed by gas chromatography.
All tools and materials that came in contact with the capacitors have to be cleaned e.g. with acetone, or be disposed of as hazardous waste.

Picture 15: Small sized capacitors

Picture 16: Sampling of small sized capacitors

Step-by-step identification of PCB Capacitors

Step 1 – Year of Manufacture:	Check nameplate for year of manufacture. If the capacitor was manufactured in or after 19**[3] → **"PCB free"** There is no SC or global regulatory policy on a deadline. The decision is based from where electrical devices were imported and experience data. Therefore it may vary from country to country, in many Countries the deadline is set on 1993 ** *Final Year and/or additional text to be provided by the countries.*	
Step 2 – Declaration:	Check nameplate for declaration "PCB" or "PCB trade name", e.g. *Aroclor, Askarel, Clophen, Delor, Elaol, Fenclor, No Flamol Phenoclor, Pyralene, Pyranol, Sovol, etc.* → **"PCB containing"**	
Step 3 – Capacitor Lists:	Compare nameplate/serial number with capacitor lists. Many devices can be identified or categorised according to information in capacitor lists. → **"PCB free or PCB suspect"**	
Step 4 – Sampling/Analysis:	If capacitor cannot be identified according to Steps 1-3 above, it must be sampled and analysed according to the procedure with transformers. Alternatively, the capacitor can be regarded as PCB containing. Please see the appropriate Factsheets.	

3. It is recommended to choose the year of manufacturing of the capacitors in line with national legislation. In case a reference year is missing in national legislation, it is recommended to use 1993 as reference year.

2.2.6 Sampling of Concrete and Brick Walls

A cordless drill can be used for taking samples. Drills (bits) with a diameter of 20 mm to 22 mm should be used to drill holes in the PCB suspected areas. The collected concrete dust from the drilling activity forms the sample for the analysis.

Safety Precautions

The drilling procedure produces dust that must be regarded as contaminated. Consequently the safety precautions during the sampling must be followed strictly and it is essential to wear:

- Leather and/or Nitrile gloves,
- Safety goggles,
- Respiratory mask with a filter for organic vapours and dusts,
- Ear protection while drilling.

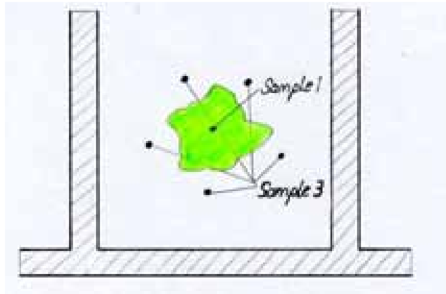
If samples are taken from a brick wall, cross contamination must be avoided by taking steps such as covering the floor with plastic liner or industrial carpet. These materials have also to be disposed of as hazardous waste.

Defining the Extent of the Contaminated Area

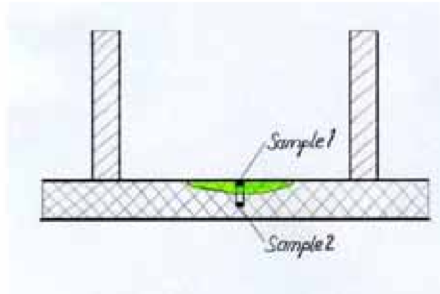
When confronted with a spill the first step is a visual inspection of the site. In most cases, the oily parts can be distinguished visually. The extent of the contamination should be investigated and the source of spill traced.

These first impressions must be verified by a few well-chosen samples. The first sample will be taken from the estimated centre, to determine whether the spill contains PCB. If the first sample indicates that PCB is present, the next samples will be taken in order to delineate the contaminated area. Not only is the size of the contamination on the surface important, but also it is essential to know the depth of penetration into the material. The limit for a sample to be considered as contaminated is 50 mg/kg (ppm), thus all samples below 50 mg/kg (ppm) can be regarded as PCB free.

In order to save costs, a strategy should be prepared to delineate the contaminated area with a small number of samples. This can be done in many ways. The appropriate strategy will be determined by the specific situation. A chosen strategy can be adapted or optimized by considering the results of an on-site analysis of the samples. An example of a visible contamination is shown in Picture 17 and Picture 18. If a rather large area can be assumed as being PCB-free, there is a way to reduce the expenditures for sampling by collecting mixed samples to verify this. Instead of taking a number of «single» samples and analysing them separately, one sample with an equal mixture from several sampling spots can be analysed in one go. If the result turns out to be well below the limit of 50 mg/kg, it can be assumed that all spots are PCB free. If the result shows a contamination around 50 mg/kg or more, the source of the contamination has to be located by further single samples.



Picture 17: Proposal strategy - horizontally



Picture 18: Proposal strategy - vertically

If the extent of the contamination is not visible a site specific strategy for the problem has to be applied. The area, where a contamination cannot be excluded, could be subdivided into a grid with equal parts with collection of a (mixed) sample in each field.

Sampling

After preparing a sampling strategy and considering the safety precautions mentioned above, the drilling can be executed. The sampling report must be filled in correctly and the sample containers marked accordingly.

Before drilling, the auger has to be cleaned e.g. with acetone, in order to prevent any contamination from former drillings.

For field analysis purposes, 10 grams of concrete or brick dust are needed, though it is advisable to take more so that the results can be double checked or verified by gas chromatography. Consider that it has to be assumed that the contamination varies with the depth of the drilled hole.

Therefore it is advisable to drill no deeper than 1.5 cm within one sample. If the necessary amount of dust cannot be obtained from this hole it is recommended to drill another one right next to it, instead of drilling deeper.

The drill dust can be collected by using a poly spoon (Picture 19) and put into the sample container. After the sampling any remaining dust has to be collected with a brush and a weighing dish and disposed of as hazardous waste. Materials that came in contact with the soil/dust have to be cleaned with acetone or disposed of as hazardous waste.

Picture 19: Sampling of concrete

Picture 20: Cleaning of leftover dust

Sampling a brick wall requires the assistance of another person who collects the drilling dust with an appropriate dish.

Sampling in Depths
Depending on the chosen strategy to define the extent of the contamination, the limits of the contamination in depth have to be verified by taking samples.

Below an explanation of the proceedings for a sampling in depths is given for an assumed depth of contaminant penetration of 10 cm:

Firstly: the area is covered with an oil pad (approx. 30 x 30 cm, with a hole in the middle of around the size of the drill bit).
Secondly: a hole with a depth of 10 cm is drilled, the dust collected and the hole cleaned. Then the oil pad is removed and disposed of as hazardous waste including the dust. The spot is then covered with a new oil pad as previously described and sticky tape is placed over the hole to facilitate the dust collecting. The drilling is continued to the required depth for the sample. The collected dust should not get in contact with the contaminated surface, otherwise or the sample will be a mixture and indicate wrong results. Finally the oil pad is removed and disposed of as hazardous waste.

2.2.7 Sampling of Soil
During the sampling it is recommended to wear:
- Disposable gloves (Nitrile or Vinyl).

If a site is heavily contaminated, the wearing of the following is recommended:
- Respiratory mask with a filter for organic vapours and dusts,
- Tyvek overall and boots.

The defining of the extent of the contaminated area works along the same principles as with the sampling of concrete and brick walls (see previous chapter). With regard to soil samples, the choice of where to take the sample has an influence on the results obtained.

Suspected contaminated areas are sites where either transformers containing PCB, contaminated transformers and/ or capacitors containing PCB are or were installed or stored. In some cases oil-stains resulting from leakage or improper storage are even visible. The soil or gravel in such areas needs special attention.

If there are no visible stains in the mentioned areas, mixed samples must be taken directly from the surface. A strategy to delineate the contaminated area should be prepared (see also sampling of concrete or walls). The samples from the surface are taken with a clean poly spoon. After the exercise the spoon must be cleaned with solvents (acetone) to prevent any possible cross contamination.

Picture 21: Sampling on surface

Picture 22: Sampling in depth (Excavation slot)

The sampling report[4] has to be filled in correctly and the sample container has to be marked accordingly. Glass vials or PE-HD plastic containers should be used.

Big stones are not appropriate for an analysis as the extraction solution to extract the PCBs for the analysis does not deeply penetrate stone. Material with *small sized gravel* or sand should be preferred.

Cross contamination must be avoided in any case. After use the scoop and all other items, which were in direct contact with the soil, have to be cleaned with acetone or disposed of as hazardous waste.

Sampling of soil and groundwater is to be carried out according to protocols, whose detailed description is beyond the scope of this guide.

2.3 Screening Test Kits and Laboratory Analysis

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

Specific methods include gas chromatography (GC) and mass spectrometry (MS) which analyse for particular PCB molecules.

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

In general, PCB specific methods are more accurate than non-specific methods but they are more expensive, take longer to run, qualified staff is needed, and they cannot be used on site.

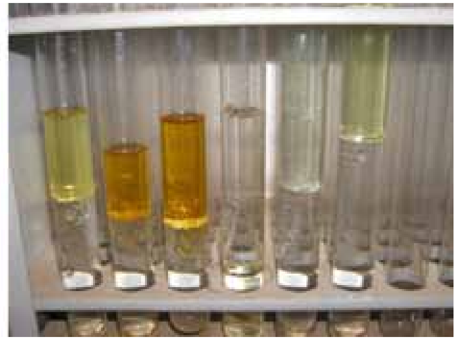
Two non-specific tests are below described that are however ABSOLUTELY NOT recommended to be used due to uncertainties in results and high potential of polluting water and air!

Density Tests

The easiest way to verify whether or not oil contains heavy concentrations of PCBs is a simple density test: ● Use a 10 ml glass vial ● pour some water into the vial ● add some dielectric liquid. If the oil layer is at the bottom of the vial the density of the oil is > 1. In such a case there is no doubt that the PCB concentration is rather high. If the oil layer remains on top of the water layer; it can be assumed that it is a mineral oil with a density of < 1.

4. The sampling report format could be used on the base of the PCB Inventory Form according to the "Regulation on criteria and conditions for handling, storage and disposal of PCBs"

Picture 23: Density Test with oil in water on a scrap yard



Picture 24: The same method in an oil laboratory

However, a density test only remains an emergency method in order to identify a pure PCB source. It cannot be recommended as a reliable tool for inventory purposes, as contaminated oil cannot be detected. Furthermore, there is a high risk of water/sewage contamination by hydrocarbons due to non-environmental conform disposal.

This test may only be performed in a laboratory by chemists in appropriate lab-chapels and/or ventilated rooms. There is a risk that highly toxic dioxins are unintentionally formed and released.

Beilstein Method

A piece of copper oxide fastened to a platinum wire is moistened with the oil to be tested and held in the outer zone of a Bunsen flame. As soon as the carbon has burned away, the presence of chlorine is indicated by the greenish or greenish-blue colour of the flame. This colour is produced by volatilizing copper chloride and its intensity and duration depends on the amount of chlorine present.

Generally, both the Density test and the Beilstein method may only be used as an emergency method, or in case of severe lack of resources and under certain circumstances.

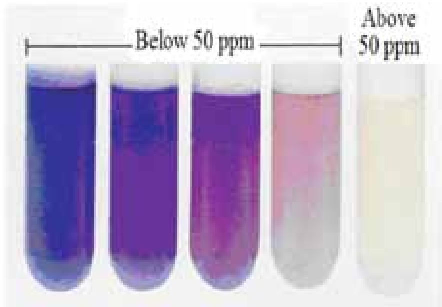
Chlorine Detection Test Kits

There are a variety of different brands of chlorine detection test kits available:

- Immunoassay technology ENVIROGARD by Millipore;

- CLOR-N-OIL and CLOR-N-SOIL by Dexsil. The Dexsil test generally distinguishes between the PCB test kits for oil (e.g. CLOR-N-OIL) and for soils (e.g. CLOR-N-SOIL).

Picture 25: CLOR-N-OIL



Picture 26: CLOR-N-OIL 50 ppm

Both Dexsil tests rely on the same principle: The chlorine atoms are chemically stripped away from the PCBs, the total chlorine concentration is determined and indicated by a colorimetric reaction. Three different test levels are available: **20 ppm, 50 ppm and 500 ppm.** Each kit is used in the same way. The end point for each has been adjusted so that it changes color at the required level. The kit is a «GO / NO GO» type of test where the result is either positive or negative.

More information and links regarding test kits and their applications can be found in Annex12.1.

Instrumental Detection of the Chlorine Concentration

Instrumental detections of the chlorine concentration are methods that use instruments or analyzers to determine the chlorine concentration in the samples.

The L2000DX relies on the same basic chemistry as the CLOR-N-OIL test kits, however instead of a colorimetric reaction; the L2000DX uses an ion specific electrode to quantify the contamination in the sample. Sample analysis is available for transformer oils, soils, water and surface wipes. The usable measurement range for oils and soils is 2 to 2'000 ppm, 20 ppb to 2'000 ppm for

water and 2 to 2'000 ug/100 cm2 for wipe samples.

The L2000DX Analyzer is pre-programmed with conversion factors for all major Aroclors and most chlorinated pesticides and solvents. The built-in methods include corrections for extraction efficiencies, dilution factors and blank contributions.

Picture 27: L2000 PCB / Chloride Analyzer

Picture 28: L2000 in use

The L2000DX can be used in the field or laboratory by non-technical personnel. An oil sample requires about five minutes to run while water, soil and surface tests take about ten minutes each. This eliminates the need to wait days or even weeks for laboratory results. Crews working at a site can take immediate action to secure equipment, isolate a site, or remove contaminated soil.

Instrument calibration is required at the beginning of each day (takes about 2 minutes). After calibrating, a reagent blank is tested to ensure the analysis is being run properly and to provide a baseline for accurate low-level results.
Blank subtraction can be incorporated into the method and is automatically updated upon calibration. The preparation steps involve extracting the chlorinated organics from the soil, water or wipe material, (not required for PCB in transformer oil), and reacting the sample with a sodium reagent to transform the chlorinated organics into

chloride. The resulting chloride is quantified by the L2000DX Analyzer. Several samples can be prepared concurrently, than analyzed in less than a minute per sample. One operator can complete about 65 oil tests, or 45 soil or surface wipe tests in an eight hour day.

Table 6: Advantages and disadvantages of field screening tests

Field Screening Tests	
Advantages	**Disadvantages**
Time: Within minutes one has proof whether the sample contains > or < than 20/50/100 ppm PCB.	Can provide false-positive results (but never false-negative)
Easy to use: The tests follow a simple procedure anyone can perform in the field or lab.	
Inexpensive: A PCB determination by test kits is less expensive than analysis in the laboratory.	
Economical: Many samples need not to be analyzed by GC at all.	

Regarding waste generated during the sampling and screening activities it is generally advised to consider all waste as PCB contaminated. Therefore, UN-approved packaging (Steel- or PE drums, Big Bags, Containers etc.) for both, liquid and solid waste must be available. Also all used reagents, test kits etc. shall be collected and disposed of as industrial waste.

Picture 29: L2000 use Practicing

Picture 30: Use of Clor-N-Soil on Site

2.3.1 Analysis by Gas Chromatography (GC)
Gas chromatography separates the components of a mixture and allows an electron capture detector to detect any compounds containing chlorine, including PCBs.

Due to their unique retention time, PCBs can usually be singled out from other chlorinated compounds using this technique. If closely related chlorinated compounds are present in the sample, then a mass spectrometry detector can «fingerprint» the PCBs and confirm their identity.

A common question is whether such analyses should be focused on mixtures of PCBs (e.g., Aroclor mixes) or on individual congeners. Congener-specific analyses have important advantages over analyses of mixtures: generally, congener analyses offer lower detection limits and greater information content. In addition, compositions of weathered, degraded, and metabolized PCB mixtures can be measured and interpreted more easily.

Also, it is easier to detect interferences caused by other chemicals, and quantification of individual congeners is more accurate. However, co-elution of analytes is a problem in a PCB congener analysis, so a strong quality assurance program and reliable reference materials are needed by the analyst.

Table 7: Advantages and disadvantages of gas chromatography

Gas Chromatography	
Advantages	**Disadvantages**
Exact results	Relatively high costs
Identification of PCB type possible	Long waiting time for result

Analyses shall be carried out by accredited and registered laboratories. Laboratories carrying out PCB analyses shall incorporate quality assurance and quality control programs.

2.3.2 Analysis Proceedings

To save analysis costs and time it is advisable to use screening tests whenever applicable. Nevertheless, it has to be considered that these methods test for the presence of chlorine in the sample being examined. 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 as if there is no chlorine present, PCBs cannot be present either.

Thus if a screening test shows a negative result (PCB below 50 ppm) it must be true, so there is no need of verification by another method.

If a test kit or the L2000 DX analyzer shows positive screening result (PCB > 50 ppm) verification by gas chromatography is always necessary.

In this case the sample for gas chromatography analysis is to be kept and forwarded to the appropriate laboratory. If results of a GC analysis show a significantly lower result than the screening tests there is no reason to be alarmed.

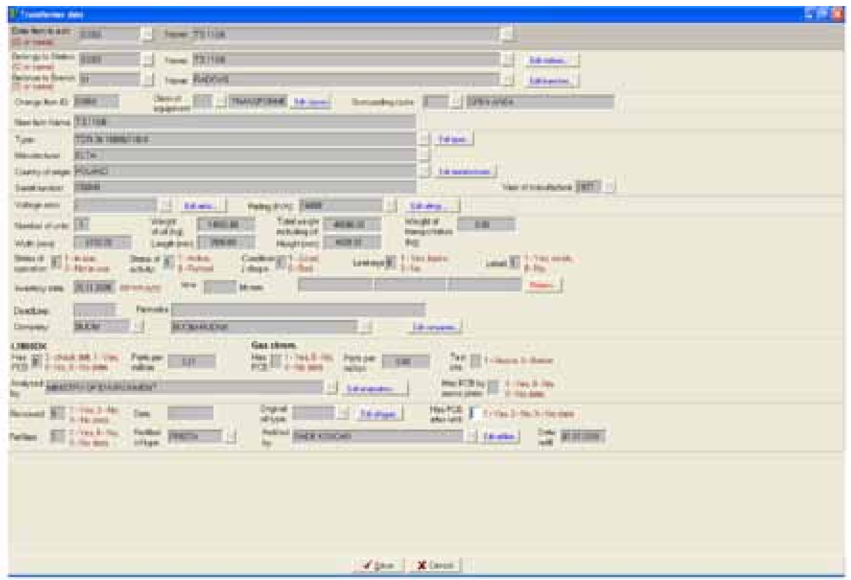
The tests are standardized for Aroclor 1242 with chlorine content of 42 %. Analyses with higher chlorinated PCB samples (e.g. Aroclor 1260 with chlorine content of 60 %) consequently show a higher result than the true PCB content. Thus the screening tests are always on the safe side.

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.

2.4 Database

The information on PCB containing equipment and its owners, which is compiled in the course of the national inventory, has to be recorded in a database:

An Access or similar database is an ideal tool to estimate the overall amount of PCB. This information is essential regarding possible project proposals e.g. for an installation of a decontamination or elimination plant in the country. The database enables the environmental authorities to control the PCB equipment in regard to the deadlines for the elimination. As the addresses of all owners of PCB containing equipment are recorded, the database can also be used if the environmental authorities have to send mailings to the owners.



Picture 31: Example of input mask of database

The database's input mask should match with the inventory form. All information from the form should be recorded in the database. The extent of the information to be declared by the stakeholders in the inventory form should include at least: general data about ownership, equipment details as dimensions, ratings, location: indoor / outdoor etc. and also information that could be essential regarding future elimination (as leakages status of PCB-screening etc.). Furthermore, data related to PCB contaminated hotspots, including sites and groundwater, should be included.

Even photographs of the equipment and eventual leakages are to be incorporated in the National PCB Database. Therefore the database software in use should cover functions to enable storage of digital pictures.

Depending on the criteria for the deadlines of elimination (see also chapter 3.3) the following information should be considered:

- Is the equipment in use or out of use?
- Is the concentration of PCB <500mg/kg or >500mg/kg
- Is the technical condition of the equipment good or bad? and
- Is the equipment located near places of higher risk (e.g. hospitals, medical centres, food industries, water and sanitation services, highly frequented buildings etc.)?

Ideally the above criteria are linked to a search or output function in the database, which enables the user to control and monitor each piece of equipment that has to be eliminated by a certain deadline.

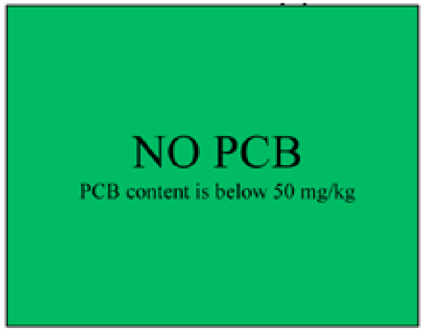
Each party of the Stockholm Convention is obliged to provide a report to the Conference of the Parties (COP) every five years on the progress in eliminating PCB. Therefore a function of the database should cover the recording and print out of all eliminated equipment in a given period.

A PCB database should not only be considered as a way to store all gathered information, but also as a tool which will be continually updated, assessed and adapted, until the last device containing PCB is eliminated (2028).

2.5 Labelling of Checked Equipment

When compiling the inventory, the inspected equipment shall be marked with labels as a precautionary measure. According to the result of the analysis of a sample or to the examination of the manufacturer's plate on a capacitor, a label as specified below will be affixed to the equipment.

This shall guarantee that the equipment can be separated easily and correctly for the disposal at the time of the dismantling activities. In addition, in case of an incident it ensures that the hazards of the situation can be assessed immediately at first glance from the color of the label.



Picture 32: Label for PCB free equipment

The equipment has been checked. Either the analysis of a sample has shown a PCB content of < 50 ppm or it has been possible to definitely determine that the equipment does not contain PCB e.g. by manufacturer's plate, nameplate, etc. (only possible with capacitors).

Picture 33: Label for PCB containing equipment

The red label is affixed to equipment where a PCB concentration of > 50 ppm has been analytically proven or if the equipment could clearly be identified as PCB containing by means of manufacturer's information e.g. name of cooling fluid. (possible with transformers and capacitors).

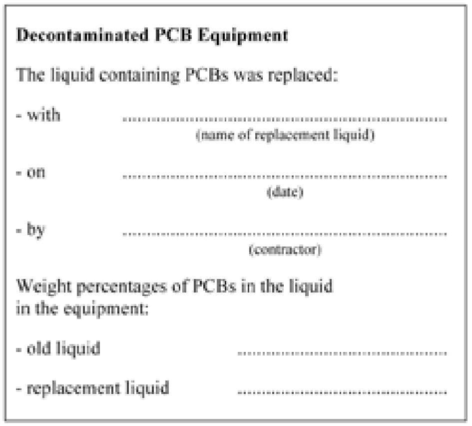
Picture 34: Label for PCB suspected

The equipment has been recorded but not yet tested for PCBs e.g. if a sampling is only possible after a phase out. Such labelled equipment remains PCB suspected, a sample must be analyzed after dismantling respectively before disposal.

It is recommended that the contracting Parties use the proposed labels, presented in pictures 32 to 34 for the purpose of easy recognition while in service, for maintenance and phased out equipment. For the export purposes countries must use additionally the labels as referred to in chapter 8.2.2 in line with the Basel Convention requirements.

Picture 35: Example labelled transformers

Picture 36: Example labelled capacitors



Decontaminated PCB Equipment

The liquid containing PCBs was replaced:

- with .... (name of replacement liquid)
- on .... (date)
- by .... (contractor)

Weight percentages of PCBs in the liquid in the equipment:

- old liquid ....
- replacement liquid ....

Picture 37: Label for decontaminated PCB equipment

Obviously, the concentration of PCB will increase after some time because of remaining PCBs in the active parts of the equipment (transformer). Therefore, a reliable measurement of the concentration is only valid after a given time after the decontamination.

The owner of decontaminated transformer should retest the oil in the transformer not before six months after treatment, and again after 2-3 months of operating time before a transformer can be reclassified.

Labels will be made by the owners of the equipment in accordance with the provisions (regarding size and material of the labels) stipulated in the Inventory Regulations.

2.6 Site Monitoring

The aim of a site monitoring is to identify all materials that could have been contaminated by equipment containing PCB during their life as a result of leaks, inexpert working practices, spills, inexpert storage or incidents. Places to investigate include concrete floors or gravel under former PCB containing equipment, concrete floor in workshops or storage sites, soil in the area of former incidents or dumping places, etc.

Site monitoring covering the entire area of a company can be regarded as the last step after the disposal or decontamination of all equipment containing PCB in that company. Nevertheless, it is also recommended to perform site monitoring on a smaller scale after the disposal or decontamination of a single piece of equipment. In this case the monitoring would only cover the area of the concerned device.

2.6.1 Land Register of Areas and Storage Facilities with Possible PCB Contamination or contaminated equipment

In a POPs contaminated areas database all spots are summarized that potentially could be contaminated by PCBs. It includes all locations where PCB or equipment containing PCB has been in use, repaired or stored.

It must also be investigated, in what locations and circumstances PCB had been used in the past. Company archives about material flow or documents about former equipment can be a useful source of information. It is further worthwhile to interview employees of the company who are or were in charge of the acquisition or maintenance of potentially PCB containing equipment.
Interviews should cover the types of purchased equipment, practices of maintenance, possible refills, stored drums with PCB for topping-ups, places of storage and workshops, incidents, etc.

The information obtained must be checked visually to substantiate the suspicion of PCB.

The places which have to be visited are:

- Current and former sites of potentially PCB containing equipment (check ground under the equipment for leaks especially),
- Current and former workshops,
- Current and former storage sites for potentially PCB containing equipment or spare insulation fluid, Sites of incidents (spills, internal failures, etc.),and Dumping sites.

All buildings where the PCB contaminated equipment is stored the following label should be affixed on building doors as indicated above.

2.6.2 Risk Assessment

To optimize the further proceedings it is advised to assess the associated risks of the sites that are listed in the POPs contaminated areas database. The questions to be considered are:

- Is the suspected PCB contamination secured or is it currently still spreading?
- Is the contamination endangering drinking water (ground water)?
- Is the location highly frequented by workers or passers-by (residential area)?
- Quantification: What is the size of the potential contamination or quantity of the endangered goods? and
- Storage: Are the suspected PCB containing goods stored appropriately (in drums or trays, sheltered, locked and separated from other goods) or inexpertly (no trays, in the open air)?

Sites that present an increased risk for humans or the environment have to be imposed with a higher priority for immediate action.

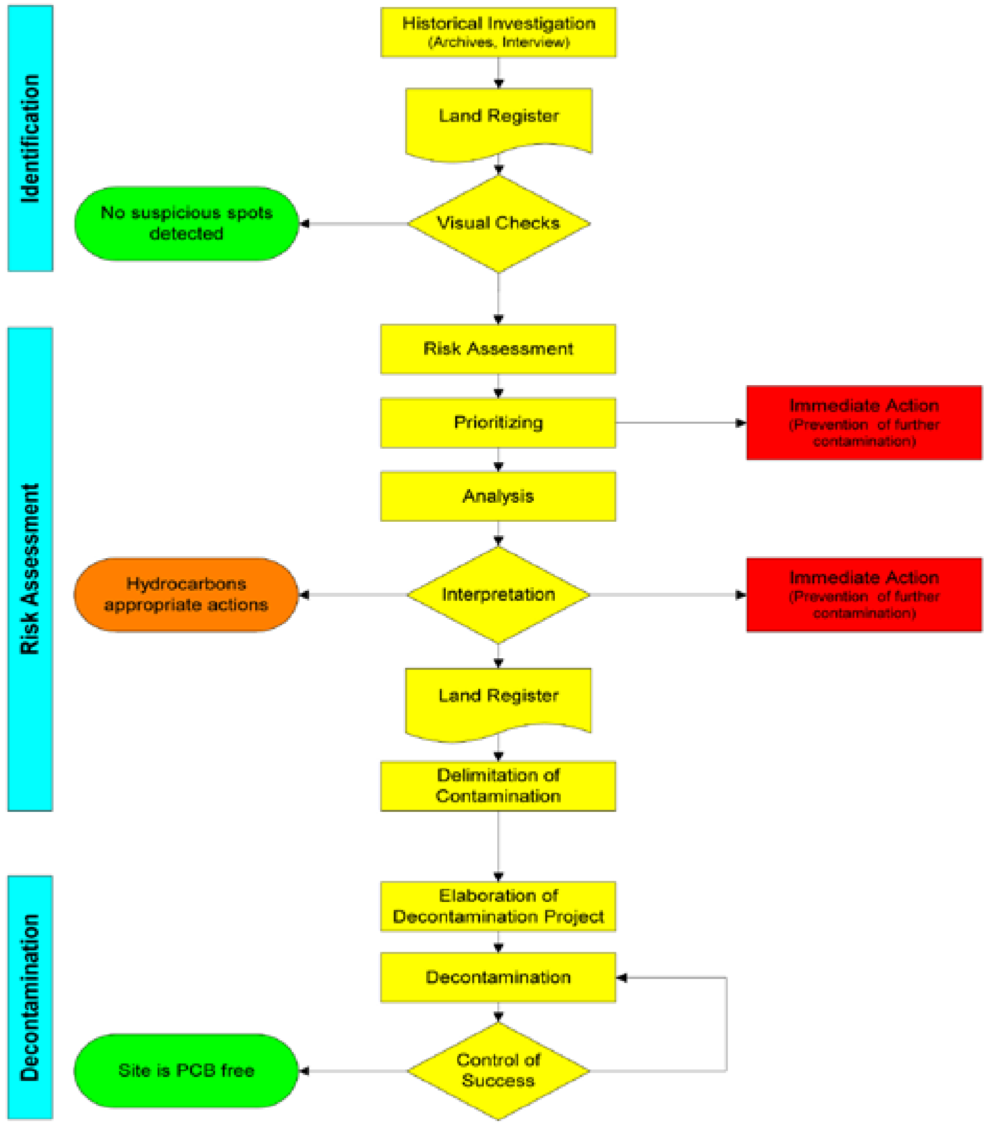
2.6.3 Analysis

In the next step a suspicion concerning possible PCB contamination has to be proved or disproved by taking and analysing specific samples. It is important to note that even if a visible spill does not contain PCB it is very likely that it does contain hydrocarbons, which are also a risk for the environment and have to be treated.

2.6.4 Extent of Contamination

When a site has been confirmed as being PCB contaminated, the extent of the contamination has to be delineated by taking further specific samples. In addition, the surrounding conditions of the site in terms of accessibility for machinery, availability of water and power, etc., need to be clarified. On the basis of the information obtained a decontamination of the site can be prepared. The following flow chart provides an overview of the procedures for a site monitoring.

Chart 2: Site monitoring – procedures



PCB MANAGEMENT OF CLOSED APPLICATIONS

3.1 PCB Management Plan

Due to the noxious properties of PCBs every owner of equipment containing PCB should prepare a PCB management plan. It must cover the whole life cycle of these products (use, handling, storage and disposal) taking into consideration the dates as per PCB regulation. The management plan should be based on the polluter pays principle and should be in line with national law, regulations and priorities. Usage, handling and storage of PCB equipment should be considered as significant aspect by organization's Environmental Management Systems and should also be considered as hazard during the occupation health and safety risk assessment. A PCB management plan includes the following components.

3.1.1 Designation of a PCB Responsible

Every company has to assign to one or several people, depending on the size of the company, the responsibilities of implementing the procedures described below. In case of a PCB incident the PCB Representative will lead the emergency procedures.

3.1.2 Training and Instruction of Staff

Staff members must be instructed periodically about the risks for humans and the environment posed by these products and the safety measures as described in chapter 5. Precautions in order to prevent contamination of PCB free transformers (e. g. by refilling with untested oil) and the measures to take in case of an incident should be revised from time to time.

3.1.3 Inventory

All equipment in and out of use that may contain PCBs has to be identified and checked (also see chapter 2.1 Inventory). All tested devices must be correctly labeled as described in chapter 2.5.

3.1.4 Database on Locations with PCB Equipment, Waste or Contamination

As described in chapter 2.5 the inventoried devices, liquids, solids, soils and wastes shall be recorded in an appropriate database. This shall enable to categorize and visualize the data, and for example show all locations with PCB transformers on a map. For larger companies and authorities such a clearly arranged plan or map can serve as a useful working tool when planning the future elimination of equipment, and help make quick decisions in case of an incident.

3.1.5 Maintenance Plan

The maintenance of PCB containing equipment as described in chapter 4. must be performed regularly. In order to control its frequency, a maintenance register has to be kept that includes all PCB equipment of the company and in which every performed maintenance activity is noted.
An example of a "PCB Equipment Monthly Maintenance Plan" follows in Annex 12.16.

3.1.6 PCB Spill Prevention, Control and Countermeasure Plan (SPCC Plan)

A SPCC plan has to be prepared to prevent spills into the environment, and to act accordingly to a situation if it should occur. More information about SPCC plan is given in chapter 3.2.

3.1.7 Disposal and Site Decontamination Plan

Equipment containing PCB and wastes must be decontaminated or disposed of solely by companies that have a special permit for treatment of such kind of materials and waste obtained by the authorized body in the field of environmental protection, or other foreign companies which provide such services and approved by the Government of their countries.
As decontamination or disposal of equipment containing PCB usually implies a great expense for a company, it is advisable to formulate a disposal plan, which defines dates of decontamination or disposal and replacement for every unit of equipment. In addition, financial planning for the disposal costs as well as for new equipment can be included in the plan.
PCB contaminated sites and soils should be decontaminated in order to avoid volatilisation and diffuse re-circulation of PCBs from contaminated water, soil and sewage sludge. Soils for example can be bio-remediated with the use of bacteria, which break down the chlorinated (and other) hydrocarbons, it can be also incinerated or extracted by means of venting (passage of air to remove vapours) or by solvent washing. The choice of technique is based on the previous analytical assessment, the extent and concentration of contamination, the matrix and the type of area (e.g. industrial, agricultural etc.). It shall also be taken into consideration that PCBs are a mixture, which may undergo biological degradation only to a certain extent. Highly chlorinated PCBs often remain intact (persistent).

3.2 Spill Prevention, Control and Countermeasure Plan (SPCC Plan)

The SPCC plan has to be elaborated to eliminate or minimize the potential environmental risk of a PCB spill, which could for example result from substation operations. The PCB Representative in the company will be in charge of the correct implementation of the following components:

3.2.1 Prevention

All doors to rooms where equipment containing PCB or wastes are located or stored must be clearly marked on the outside with a label. The use or storage of PCB transformers is prohibited in any location where human food or animal feed products could be exposed to PCBs released from the transformers. The storing of inflammable materials next to equipment containing PCB or waste is forbidden. Best working practices as described in chapter 4.2 have to be followed.

3.2.2 Spill Prevention Tools

Under each transformer a retention system has to be installed to prevent the dissemination of PCB into the environment in case of a leak. The best solution is a steel tray, however concrete or brick walls around the transformer are also acceptable as long as the basin is tight and its retention volume is greater than the volume of the fluid in the transformer. In case of concrete basins they obviously should contain an oil resistant paint (e.g. appropriate kind of Epoxy). Spare equipment or equipment out of use and other PCB wastes must be stored in steel drums or steel trays as described in chapters Error! Reference source not found.7 and 8.

Picture 38: Labelling of a transformer room door

Picture 39: Retention system made from steel

The floors of workshops for activities like draining and dismantling of transformers has to be tight and fairly easy to decontaminate (e.g. Epoxy coating). The thresholds have to be elevated and all other openings close to the floor have to be sealed to prevent the dissemination of PCB into the environment in case of a spill.

3.2.3 Countermeasure

Emergency response plans as described in Annexes 12.8 and 12.9 have to be affixed near equipment containing PCB in an easily visible spot. In order to be able to react immediately in case of an incident it is recommended to keep appropriate materials and tools for immediate actions in an easily accessible place (protective gloves, drip tray, repair material, absorbents to seal leaks, etc.). Such storage depots can be recorded in the PCB register to allow immediate access in case of emergency.

3.3 Priorities for Disposal and Site Decontamination

According to the risk that PCB containing equipment or contaminated sites and soil pose to humans or the environment there are different priority levels. These shall be stipulated in the national PCB regulation:

(1) PCBs that are stored as spare oil, as waste or as electrical devices out of service have to be disposed of no longer than three years after their declaration to the Competent National Authority in the frame of the national inventory,

(2) PCB containing electrical devices
- of PCB concentrations higher than 0.05 mass percentages (500 mg/kg)
- in a bad technical condition
- situated near places of a higher risk for the people (hospitals, medical centres, commercial centres, schools and universities, food industries, water and sanitation services, highly frequented buildings) have to be decontaminated or disposed of with priority,

(3) All other electrical equipment with a PCB concentration between 0.005 and 0.05 mass percentage (50 and 500 mg/kg) can remain in service until the end of their useful life, but no longer than the year 2025, and

(4) PCB polluted soil and/or sites with direct impact to the environment or potential health risks, such as but not restricted to e.g. PCB contaminated agricultural land or sites close to food processing areas. Particular importance should be given to get better insight in unknown sources, equipment or hotspots.

MAINTENANCE OF EQUIPMENT CONTAINING PCB

The maintenance of a device should be performed according to the procedures issued by the manufacturer and by the corresponding national standards. In the following, a general view of the key elements of the maintenance of PCB containing transformers and capacitors is presented.

4.1 Maintenance of In-Service PCB Equipment

In-service equipment containing PCBs may need to be maintained according to the manufacturer's instructions for proper functioning or to clean up or prevent releases of PCBs. It is not within the scope of this document to discuss routine maintenance of equipment. The maintenance issues that are of importance for PCB Management are:

1. Transfer of liquid PCBs during maintenance
2. Replacement of leaking seals and repair of cracks and holes
3. Clean-up of minor leaks or spills during maintenance activities

All work on PCB containing equipment should be carried out in accordance with the site specific health and safety plan and applicable government regulations. Staff should be trained in the maintenance of the equipment and in the correct methods to handle hazardous materials.

If a piece of equipment containing liquid PCBs needs to have internal components "topped-up" or recharged, serviced or repaired (and is the type of equipment that is normally opened for servicing) serious consideration should be given to replacing the equipment or decontaminating it (removing the PCBs) and re-filling it with a non-PCB fluid. The Basel and Stockholm Conventions recommend phase-out of this equipment (under specific timelines) rather than continued use. Replacement fluids for electrical transformers include silicones, aliphatic hydrocarbons, poly- - olefins, chlorinated benzenes and esters (Environment Canada, 1988).

If servicing of equipment is unavoidable, all work should be done with the objective of minimizing releases to the environment and minimizing the amount of contaminated material created through the servicing work. Recommended practice for this purpose includes:

- Plan the servicing in accordance with the manufacturer's recommendations, applicable regulations and codes and with the advice of experienced professional service persons.
- Turn the equipment off and disconnect it from the power source. De-pressurize the equipment if necessary. Allow the equipment and PCB liquid to cool to ambient temperature. Servicing equipment at ambient temperatures above 25°C should be avoided if possible due to the increased volatility of the PCBs at higher temperatures (i.e. more PCB vapours will be released at higher temperatures).
- Inspect the equipment before beginning service for leaks, holes, rust, low fluid level, high or low pressure (above or below specifications), high temperature (above specifications), malfunctions and gaseous emissions.
- Inspect the opening valves, latches, lids, etc. for blockages, breakage or malfunction.
- Re-consider and re-plan the servicing plan if any leaks, holes, malfunctions etc. are found.
- Ensure that spill containment measures are in good shape and adequate to contain the PCB liquid if spilled. It may be advisable to place plastic sheeting or absorbent mats under the equipment before opening it if the surface of the containment area is not coated with a smooth surface material (paint, urethane, epoxy, etc.).
- Additional ventilation may be required to keep the atmospheric PCB level below the recommended levels and to provide adequate oxygen for workers.
- Remove the liquid PCB either by removing the drain plug or by pumping with a peristaltic pump and Teflon or silicon tubing. Store the PCB liquid temporarily in one or more steel containers (drums) with tight-fitting lids or bungs. Leave a space of 8-10 cm at the top of the container for heat expansion and to avoid spillage when opening the container. Pumps, tubing and drums should be dedicated to the transfer of PCB liquids (not used for any other purpose).
- Inspect the inside of the equipment for damage, rust and cracks. Complete servicing and repairs.
- Replace any worn or broken seals.
- After completing the servicing replace the drain plug if applicable, replace the PCB liquid by pumping, add make-up fluid if necessary, and re-seal the equipment.
- Clean up any spills with cloths or paper towels. Triple rinsing contaminated surfaces with a solvent such as kerosene is usually necessary to remove all of the residual PCBs.
- All tools used for the servicing should be dedicated for PCB use.
- All absorbents, disposable protective clothing, plastic sheeting and removed components should be treated as PCB waste.

4.2 Best Working Practices

When performing light repair or maintenance work on PCB containing equipment, the following safety precautions for the protection of the employees and the environment have to be taken:

- Direct contact of the skin with PCB contaminated materials must be avoided by wearing gloves and safety goggles. According to the type of work to be performed, protective clothing and a respiratory mask must also be put at the workers' disposal (see also chapter 5.1. Personal Protective Equipment),
- The working area must be adequately ventilated,
- Spills must be prevented in every case by using drip trays or adequate plastic tarps,
- Every contact of PCBs with a flame or any other heat source over 300 °C and use of a grinder must absolutely be avoided (risk of highly toxic Dioxins and Furans),
- All used tools and other working materials that got in contact with PCBs must be disposed of as PCB contaminated waste in an environmentally sound manner or otherwise have to be decontaminated with an appropriate solvent (technical acetone). The only possible materials to be decontaminated are steel, glass, and ceramics. All other materials, such as rugs, PPE, etc. must be disposed of as hazardous wastes; tools and certain equipment (e.g. pumps and hoses) may be re-used but only for operations with PCB-containing equipment and must therefore be clearly marked/labeled as PCB-contaminated,
- Operations which involve draining, rewinding of coil, etc. may only be performed by companies approved for such tasks by the competent country authorities.
- The role of universities, NGOs and related stakeholders in promoting the dissemination of PCB management's best practices shall be strengthened.

In Annex 12.11 a proposal of a flyer can be found. It is recommended to print and distribute this flyer to owners of equipment containing PCB, so they can affix it to walls near the equipment or in workshops.

Picture 40: Transformer maintenance area

Picture 41: Active transformer part in Albanian workshop

4.3 Inspection of PCB Containing Transformers

4.3.1 Visual Checks

The simplest and the cheapest test of a transformer in service or in storage is the visual check. PCB Transformers shall be visually inspected quarterly by the equipment owner, who is also responsible for maintaining records of inspections.

The following areas shall be examined:

- Oil stains near the equipment
- Oil stains or weep marks on the equipment (welding seams, gaskets, valves, etc.
- Gross physical damage
- Tightness of drip tray

Table 8: Routine inspections for transformers

Inspection	What to look for (and corrective action)
Condition of gauges	➢ Cracked faceplates or damaged gauges (install a Plexiglas sheet over gauges for protection).
Reading of gauges	➢ Change in readings since last inspection. ➢ Readings within the safe or acceptable range (if they are not, consider the addition of make-up fluid).
Corrosion on tank and radiator fins	➢ Condition of fins. They are manufactured of thin steel to obtain maximum cooling and will rust through more quickly than the rest of the transformer, especially in a caustic environment (clean to bare metal and paint if rusted).
Paint finish of tank and radiator fins	➢ Weathering paint (repaint as often as necessary).
Leakage of PCB from: ➢ tank ➢ radiator fins ➢ top cover (if gasketed) ➢ manhole cover ➢ top or bottom drain spout ➢ high and low voltage bushings	➢ Wet slickness and gummy residue. ➢ Deteriorating gaskets or seals. (Important – if there has been leakage, take steps to clean it up promptly and reported to the appropriate provincial authority. All materials used for cleaning up the PCB leakage must be safely stored as PCB-contaminated waste.)
Pressure-relief valve	➢ Improperly seated valve due to displaced gaskets.
High and low voltage bushings	➢ Cracking or chipping. (Replace cracked or chipped bushings.)
Colour of PCB	➢ Colour changes. ➢ Take a small sample. If the color is changing from clear to a blue, green, red or black, the PCB is becoming contaminated (consider a laboratory test to check its quality).

4.3.2 Leaks of Transformers

When a leak or spills have been detected on or near a transformer, it is necessary to look into the cause of the leak to prepare remedial action. Most common are leaks at seals and gaskets. Various possibilities for effective reparations are apt and help avoid affecting the main body of the transformer in any way. However, only experienced electrical specialists who are aware of the dangers of PCBs shall perform such work. A more serious situation occurs when the leakage or seepage is due to damage in the metallic structure of the transformer.

Such leaks can be caused by mechanical and accidental damage to the transformer casing. In such cases, it is recommended to seal the leak temporarily with a sealing paste and place a drip tray underneath the leak for safety reasons. As this is only a temporary solution, a proper repair has to be carried out soon as possible.

A leak can also be caused by a slow degradation of the cooling fluid, which increases its corrosiveness. If corrosion is already advanced and causing leaks, then the transformer must immediately be sealed

with a sealing paste, phased out as soon as possible and replaced by a new device.

4.3.3 Oil Level of Transformers

Most transformers have a direct or indirect device allowing the cooling fluid level to be controlled. Before topping up a decreased cooling fluid level, it is vital to check the PCB content of the transformer as well as the additional cooling fluid to avoid a possible contamination.

4.3.4 Temperature Gauge

The temperature gauge indicates the temperature of the dielectric fluid within the transformer. Excessive temperatures point towards an overheating of the transformer, possibly due to loss of dielectric fluid. Action should be taken immediately to detect the cause of the overheating, as the rate of the deterioration of insulating materials in the transformer can rise rapidly above the normal operating temperature.

4.3.5 Pressure-Vacuum Gauge

The pressure-vacuum gauge measures the pressure changes in the space between the dielectric liquid and the tank lid. Unusually high pressure indicates that short circuits and arcing may have occurred. In this case, a performance test has to be performed as soon as possible. An unusually low pressure reading indicates a low level of the dielectric fluid. Action should be taken immediately to identify the cause of the dielectric fluid loss.

4.3.6 Corrosion on Tank and Radiator Fins

The condition of the tank and the radiator fins has to be checked regularly, as they are prone to show corrosion. If corrosion occurs, the affected area has to be cleaned to the metal and painted.

4.3.7 Performance Tests

Transformers must be periodically checked to detect any changes which may be the first signs of degradation in the performance of the transformer, and therefore of possible risks arising. Among others, the following characteristics have to be checked:

- Functioning of all protection devices
- Electrical performance of the transformer
- Oil quality (physical and chemical tests)

4.4 Evaluation of PCB Containing Capacitors

Visual checks are easy and they can be carried out frequently if the conditions in the substation require so.

Visual checks allow detecting the following damages on capacitors:

- Leaks in the container
- Swelling out or deformation of the container
- Oxidation of the container
- Dirty bushings

In the first two cases, the capacitors must be phased out immediately and disposed of in an environmentally sound manner.

The swelling of the container is a clear indication of a soon short circuit in the capacitor!

Picture 42: Inflated capacitor

Visual checks must be complemented by technical examinations, which require qualified staff. Depending on the condition of the equipment, the frequency of the examinations is determined (at least once a year).

4.5 Substitute Fluids

PCB oils in transformers have often been replaced by common mineral oils like «Shell Diala B». However, other substitute fluids have also been used. The table below lists substitutes fluids for new transformers, together with their advantages and disadvantages.

Table 9: Substitute fluids

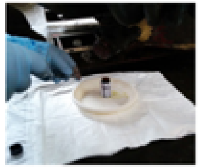
Substitute Fluid	Advantages	Disadvantages
Silicones	➢ low pour point ➢ high fire point ➢ low rate of heat release upon combustion ➢ fairly low viscosities over the entire range of operating temperatures	➢ not compatible with some gasket materials, such as silicone rubbers and certain insulation materials. ➢ specific gravity of fluid is such that water will sink to bottom of transformer while ice crystals are buoyant and float to top. Melted ice crystals could migrate through fluid and reduce its dielectric strength ➢ cost is relatively high ➢ PCBs are soluble in silicones only up to 8 %
Aliphatic hydrocarbons (e.g., RTEmp, produced by extensive refinement of crude oil and blending of anti-oxidants, stabilizers and other additives)	➢ low degree of in-service degradation ➢ compatibility with all materials of construction normally used in electrical equipment ➢ fluid is compatible with all other dielectric fluids ➢ specific gravity is below that of both water and ice ➢ fluid is not a serious environmental hazard (same effects as other mineral oils), is biodegradable and can be disposed easily ➢ cost I lowest of all PCB substitutes and raw materials are plentiful	➢ high viscosity at lower temperatures ➢ high rate of heat release during combustion ➢ blended additives (proprietary to the supplier) are required to depress pour point and improve thermal and oxidative stabilities ➢ gassing tendency under electrical stress is equal to or higher than for conventional (naphthenic) transformer oils which are in turn higher than all other PCB substitute fluids
Poly-a-olefins (synthetic hydrocarbons)	➢ compatibility with all materials used for transformer construction and all other hydrocarbon fluids ➢ lower pour point and slightly better low temperature viscosity than natural aliphatic hydrocarbons ➢ specific gravity below that of water and ice ➢ no gassing under electrical stress	➢ relatively high rate of heat release during combustion ➢ relatively high cost
Chlorinated benzenes (Tri-tetrachlorobenzenes are components of PCB but can also be use alone)	➢ physical properties similar to properties of PCB ➢ transformers designed for PCBs are generally suitable for TTCBs	➢ not suitable for use at very low ambient temperatures because of high pour point ➢ exhibit some toxicity and not easily biodegradable
Esters (blend of pentaerithritol and fatty acids)	➢ high dielectric strength ➢ low flammability ➢ low pour point ➢ no toxic substances generated during arcing conditions ➢ compatible with most materials used in transformers	➢ no significant disadvantages except higher cost than RTEmp fluid

SAFETY

5.1 Safety and Personal Protective Equipment

People handling PCBs or people that can be potentially exposed to PCBs have to use adequate protective equipment. The level of protection and the choice of protective equipment depend highly on the tasks carried out.

Table 10: Description of personal protection equipment (PPE)

Task	Personal Protective Equipment
Sampling of liquids or soil 	➢ Gloves (Vinyl or Nitrile, no Latex) ➢ Light respiratory mask (Filter A2P2; for organic vapors and particles, voluntary)
Sampling of a capacitor	➢ Gloves (Vinyl or Nitrile, no Latex) ➢ Safety goggles, only while opening or drilling ➢ Light respiratory mask (Filter A2P2; for organic vapors and particles)
Sampling of concrete or brick wall (e.g. by drilling)	➢ Leather gloves ➢ Safety goggles while drilling ➢ Light respiratory mask (Filter A2P2; for organic vapors and particles) ➢ Ear protection (while drilling)
Dismantling of capacitors (no leakage) 	➢ Working overall ➢ Helmet (according to companies' safety rules) ➢ Steel capped (rubber) boots ➢ Leather gloves ➢ Light respiratory mask only in case of leakage (Filter A2P2; for organic vapors and particles)
Dismantling of capacitors (with leakage) 	➢ Protective suit (Tyvek) ➢ Steel capped (rubber) boots ➢ Neoprene gloves ➢ Light respiratory mask (Filter A2P2; for organic vapors and particles)
Clean-up activities (choice of PPE according to type of contamination and extent of work)	➢ Protective suit (Tyvek) ➢ Steel capped rubber boots ➢ Safety gloves (heavy duty) ➢ Respiratory mask (light or full face, Filter A2P2; for organic vapors and particles) ➢ Helmet (if necessary) ➢ Ear protection (if necessary)

The most important parts of Personal Protective Equipment (PPE) for handling PCB-containing materials are shown below:

Picture 43: Protection overall, one way, oil-resistant

Picture 45: Breath protection masks, light, FFP2 or 3

Picture 44: Safety gloves, Neoprene

Picture 46: Breath protection masks, medium, A2/P3

Table 11: Filter classification

Letter	Definition
A	High-boiling (>65 °C) organic compounds
P	Particles; classified as P1, P2, and P3 according to removal efficiency
ABEK, ABEK-P3, ABEK-HgP3	Combination filters against multiple hazards

Table 12: Particle filters

Class	Filter Penetration Limit
FFP2	Filters at least 94% of airborne particles
FFP3	Filters at least 99% of airborne particles

The appropriate choice of masks and filters respectively PPE in general shall be based on a risk evaluation, as other hazardous substances could be present depending on site, area and tasks to be performed.

Picture 47: Safety gloves, Nitrile, EN 388, oil resistant

Picture 48:Safety goggles

One-way gloves for the sampling of liquids should be made of Nitrile or Vinyl. Latex or
Butyl rubber gloves should not be used as PCBs might penetrate through them!

Protection of the Environment
When handling PCBs, all necessary safety precautions need to be taken in order to prevent a contamination of the environment.

When taking samples of PCB suspected equipment or PCB suspected material, it must be worked tidily without losing or spreading sample material. Use oil absorbing carpet as foundation if needed.

All working material must be cleaned either with acetone or disposed of as hazardous waste, including PPE. Only metal and glass can be cleaned entirely, synthetic material and plastic, wood, etc. cannot be cleaned and have to be disposed of as hazardous waste.

When confronted with leaking equipment or equipment in bad technical condition during the inventory, it must be ensured that the leak can be stopped or that the entrainment of the contamination can be prevented.

In areas with spills: The contaminated area shall be marked and fenced off if possible. Clothing and footwear shall be changed when entering or leaving the contaminated area in a designated place (compartment).
If possible, the leak shall be located and sealed e.g. with a sealing paste. Furthermore, the leaking device shall be placed in a steel basin or drip tray when out of service otherwise absorbent pads shall be placed around and replacement foreseen as soon as possible.

In case of leakage due to damaged equipment, uncontrolled spillage must be prevented by the appropriate positioning of a drip tray, as a first measure. Small leaks should be sealed, and suitable safety equipment must be used while carrying out this work. It is therefore advisable to always keep suitable material (drip tray, rubber gloves, sealing material) in the vicinity of such equipment.

Visibly contaminated soil or concrete should be removed as quickly as possible in order to avoid further contamination. Surfaces of objects (vehicles, sidewalks, buildings, etc.) should be cleaned by using oil absorbent materials and by wiping the surface with solvents. After the cleaning, the surfaces must be analytically tested to check the cleaning success. The used cleaning materials should be placed in drums for disposal.

EMERGENCY ACTIONS AND CLEAN UP

Emergencies involving PCBs can occur with equipment in service, in storage, during transport or at a disposal facility. These emergencies may take the form of:

- A leak or spill of PCB liquid
- The failure of a piece of in-service equipment
- The accidental breach of a container of PCBs
- Fires

All companies operating storage facilities or transporting PCBs should develop and implement a fire and emergency action plan. Such a plan should be developed in conjunction with the local fire department.

All personnel working with PCBs should become familiar with the contents of the emergency plant. It is recommended that employees be trained in the use of the plan, preferably through emergency drills. As well, employees should be trained in the use of personal protection equipment, spill control kits, and fire extinguishers. They should also be made aware for the hazards of PCBs.

In case of incidents, accidents or spills the company shall notify all competent authorities in line with national regulation and environmental permit standards.

6.1 Emergency Actions for Cold Incidents

The seeping of PCB from a device in the environment is described as a «cold incident». Cold incidents can be caused by unintended mechanical damage to the transformer's cooling fins or by corroded transformer walls. Spills can, however, also occur during draining activities or the handling of stored oil.

The following measures must be taken:

Measures in case of «cold incidents»

- If a lot of PCB has leaked from the equipment and if there is a risk of the PCB contaminating the environment, the chemical brigade must be called immediately. If there are doubts whether or not the oil does contain PCB, then the oil should be regarded as containing PCB until the contrary has been proven.
- Inform the doctor in charge and equip the chemical response team with appropriate personal protective equipment according to chapter 5.1.
- Switch off the power supply to the concerned device and check grounding.
- Limit the spreading of the seeping oil by sealing the leak and using absorbing materials (sand, sawdust or cement) or by pumping in appropriate containers. If possible, a drip tray can be placed under the leak.
- Prevent the contamination of watercourses by PCB. Drains as well as channels and pipes that lead to open waters must be sealed. Furthermore, it must be ensured that no water can flow into the contaminated area (e.g. sprinkler systems). Consider: A pollution of watercourses or puddles does not necessarily have to be visible. PCB is heavier than water and thus there is no oil film on the water.
- Fence off and mark the contaminated area. A tent with different compartments must be set up to control the access of people and the movement of material into or out of the contaminated zone, in order to prevent clean areas from being contaminated. The personal protective equipment is put on/taken off in the tent every time when entering/leaving the contaminated zone.
- Within the contaminated zone, attention must be paid to the soles of the shoes. They must be clean; otherwise the floor could be contaminated with PCB by the soles.
- The contaminated floor or concrete should be removed as quickly as possible to prevent a further cross contamination.
- If the incident has happened inside a building: Evacuate people from all concerned rooms/buildings, switch off ventilation, close doors, and windows.
- Inform the competent authorities. All details about the incident have to be reported so that the population can be warned, if necessary (e.g. contamination of drinking water)

An Emergency Response Plan for cold incidents is given as a checklist for separate distribution in Annex 12.8. This checklist shall be regarded as a basic list and adapted to current actualities including contact addresses of competent authorities.

6.2 Emergency Actions for Hot Incidents

Incidents involving PCB equipment can also be caused by short circuits or a fire in the vicinity of the equipment. In case of a «hot incident», the temperature in the device exceeds the boiling point of PCB (approx. 300 °C).

If this happens locally even for a short time only (e.g. short circuit), PCB vapors can be released, and they can contain highly toxic Furans (PCDFs). If PCB gets in contact with oxygen (fire), not only Furans, but also Dioxins (PCDDs) can be formed.

6.2.1 Incident Caused by an Internal Failure

An electrical short circuit (arc) constitutes the greatest danger. In a capacitor, it gives rise to temperatures of several thousand degrees Celsius within fractions of a second.

Failures of this kind primarily occur in capacitors. The heat causes excess pressure in the equipment, resulting in the bursting of the capacitor. A black, viscous mass leaks out. This is PCB containing carbon black. Due to the increased temperatures gaseous PCB is formed, which is contaminated by Furans. These vapors can deposit viscous oil films on fittings, floors and walls, even at a distance from the place where the incident happened.

In addition to the measures mentioned in the previous chapter, the following points must be considered:

- Personal protective equipment must absolutely include respiratory protection.
- Lock the building immediately and stop air circulation by closing/sealing ventilation slits, if possible.
- Evacuate people from all rooms at risk.

Picture 49: Hot incident

Picture 50: Burst capacitor

Picture 50 above shows the former position of a burst capacitor within a capacitor battery. The oil squirted out and contaminated the wall behind the capacitors.

6.2.2 Fires

Fires of transformers or capacitors have been very rare. The causes of incidents usually were fires in the vicinity of the PCB containing equipment.

During a fire, there is danger of a decomposition of PCB caused by the heat and the effect of oxygen. Hydro-chlorinated gas is formed and the decomposition process can also result in highly toxic Furans (PCDF) and Dioxins (PCDD).

Picture 51: Fire near a substation

Picture 52: Remains of transformers in a scrap yard

The order of the measures to be taken in case of a fire is given below:

- Call the fire brigade immediately and carefully describe the situation so that the appropriate equipment can be chosen for the fire-fighting operations. If there are doubts whether or not the devices do contain PCB, then they should be regarded as containing PCB until the contrary has been proven. Calling the fire brigade immediately can highly reduce the effects of an incident.
- Inform the doctor in charge and equip the chemical response team with appropriate personal protective equipment. The protective equipment proposed in chapter 5.1 is not sufficient for areas where Dioxins and Furans have been released (and hardly kept handy everywhere). Consequently, the chemical response team should only approach the danger zone if absolutely necessary.
- Switch off power supply.
- Hermetically seal the rooms or the entire building. Switch off ventilation systems.
- Evacuate people from all concerned buildings, and on a larger scale in the direction of the wind.
- Inform the competent authorities: All details about the incident have to be reported so that the population can be warned or evacuated, if necessary.
- Fence off the contaminated zone and strictly control access. Only people wearing appropriate personal protective equipment are allowed to enter the zone. When fencing off, the direction of the wind must be considered.

An Emergency Response Plan for hot incidents as a checklist for separate distribution can be found in Annex 12.9.

Instructions for the fire brigade should include:

- To use CO2 to extinguish the fire
- If water is used at all, then only to cool down the environment
- If water is used, it must not flow into the sewage system or open waters (pump!)
- To ensure that all skin is covered to prevent exposure to smoke containing PCBs
- Clothes and protective clothing that has come into contact with PCB or decomposition products (soot) must be regarded as being toxic and disposed of appropriately
- All firemen should shower thoroughly to remove any soot that may have contacted uncovered skin
- If a fireman develops a skin rash after a fire, he should go for a medical check-up

6.3 First Aid in Case of Contact with PCB

The following table summarizes the immediate actions that have to be taken after an exposure to PCB. Additionally, a doctor should be seen in any case.

Table 13: First aid measures

First Aid Measurements		
Kind of Exposure	First Action	Second Action
Liquid PCB on the skin	Use water and soap to wash thoroughly	See doctor if rash develops
Liquid PCB in the eyes	Rinse eyes with lukewarm jets of water for 15 minutes, always keeping eyes wide open*	See doctor
Liquid PCB in the mouth and in the stomach	Rinse mouth with water, do not drink anything else	Write down details about swallowed liquid, take victim to hospital emergency or doctor immediately
Highly concentrated vapors of PCB	Take affected people outside in the open air	If discomfort does not clear up, take victim to doctor

6.4 Clean Up after Incidents

6.4.1 Assessment of an Incident

In case of an incident, the operator/owner of the equipment must try to obtain the following information immediately, to enable a first assessment of the situation:

- Do the concerned devices really contain PCB?
- Is the PCB concentration known (e.g. from earlier analyses)?
- What is the assumed extent of the PCB or PCDF/PCDD contamination?
- Are there any visible billows of smoke, soot deposits?
- Weather conditions: Direction of the wind, wind force, rain, snow?
- Is the sewage system or the groundwater affected?
- Access roads used for possible fire-fighting operations (cross contamination)?

- When and where exactly did the incident happen (order of events)?
- If the incident happened in a closed room, it shall be reported if ventilation was in use and when it was switched off, respectively. Additionally, the names of all the people that came in contact with PCB or smoke shall be listed (for medical care, if necessary).

The assessment of the incident, which is done by experts, highly depends on the quality of the obtained information/ responses to the above questions. Based on the received information, the experts take samples that are analyzed to determine the extent of the contamination. Cleaning activities should only be started with after the availability of the results, except for immediate actions, e.g. to control oil spills (to prevent a further contamination of soil, concrete and air).Incidents should immediately be reported to the competent authority in the field of Environmental Protection and Emergency Situations.

6.4.2 Decontamination Methods

The decontamination technique depends on the extent of the contamination; the pollutant(s), the concentration, and the contaminated material itself (concrete, soil, ceramic, plastic, etc.).

Table 14: Decontamination methods

First Aid Measurements

l: low concentration, dry, non-sticky soot, no visible oil film

h: high concentration, visible oil film, spills, puddles, sticky soot

Material	Technique (l)	Technique (h)
Soil	Remove until material is below the limit of 50 mg/kg	Remove until material is below the limit of 50 mg/kg
Uncoated concrete floors	Use industrial vacuum cleaners with appropriate filters and wet wipe the floor	Repeated solvent scrub process followed by an absorbing clean up, until material is below the limit of 50 mg/kg
Walls, brick walls	Use water to clean, or remove plaster	See concrete floors
Ceilings	Use industrial vacuum cleaners with appropriate filters to clean and wet wipe the ceilings	See concrete floors
Untreated metal, window panes	Use solvents to clean carefully	See above
Coated metal surfaces	Use solvents to clean	Completely remove coating
Plastic parts (insulating material, etc.)	Use solvents to clean	Remove, replace
Fittings	Dismantle completely and use solvents to clean	Clean or remove, depending on concentration and quantity

The choice of the appropriate solvents or cleaning agents shall be made from case to case. It is recommended to use technical acetone to clean soot, dust, and similar materials. Spills are best cleaned by means of a biodegradable cleaning agent.

Visibly contaminated soil or concrete shall be removed in order to avoid further contamination. Surfaces of objects (vehicles, sidewalks, buildings, etc.) should be cleaned first by using oil absorbent materials and then by either a solvent scrub process or rather by using a biodegradable cleaning detergent. After the cleaning, the surfaces should be analytically tested to check the cleaning success. The decontamination process has to be repeated, until the remaining contamination is lower than the applicable limit value (50 mg/kg). If this procedure does not lead to a success, the structure has to be removed.

Spills into waters could pose a difficult clean-up problem and require special consideration. Since pure PCBs are denser than water, they will settle to the bottom and dredging of contaminated sediment will be necessary.

6.4.3 Protection of Workers and the Environment

In certain serious cases, the contaminated area should be sealed off by a protective tent around the zone. Such a tent must be air- and dust-tight, protect against the weather and control access by a system of compartments. The contaminated zone must only be entered through this system and personnel must wear personal protective equipment (PPE) when entering. The purpose of the sealing off is to prevent a cross contamination in the environment. A controlled exhaust system installed at the tent collects and filters (by an activated carbon filter) contaminated dust and particles that are formed during the clean-up activities.

6.4.4 Disposal

The appropriate disposal of the wastes is a very important part of clean-up activities after a PCB incident. Unfortunately, this aspect is often underestimated during the planning phase. Not only contaminated soil or removed contaminated building material, but also associated wastes like vacuum cleaner bags, solvents, personal protective equipment, cleaning material, sealing-off material, etc. must be disposed of in an environmentally sound manner. Please find more details about disposal in chapter 11.

6.5 Check of Clean Up (Monitoring)

The supervision of clean-up activities by an independent expert and/or representatives of the responsible authority is a key element of success and should be regarded as useful assistance. Representative sampling during and at the end of the clean-up activities shall prove that the remaining contamination does not exceed the tolerable and agreed values.

6.5.1 Tolerable Remaining Contamination after a Clean-up

The guide values for tolerable remaining contamination shall be decided in cooperation with the competent environmental authorities in case by case decisions. Furthermore, the control of the contamination after the clean-up shall be regulated. It can make sense to determine the limit values from case to case, depending on the project.

The following values can be regarded as a guidance based on limit values in various European Countries. Of course, the specific limit values of a country depend on its national laws and regulations.

Table 15:Proposed general guide values

Description	Substance	Guide value	Unit
Surfaces (for example cleaned/decontaminated metal surfaces)	PCB	100	µg/m²
Solids (for example concrete, building materials, etc.)	PCB	50	mg/kg
Indoor Air Rooms with a stay of eight hours per day (Intervention value)	PCB	> 6'000	ng/m³
Indoor Air Rooms with permanent stay (Intervention value)	PCB	> 2'000	ng/m³
Indoor Air Value to be achieved after a PCB clean-up	PCB	300	ng/m³

PHASE OUT

7.1 Phase Out of Transformers

The practical phasing out of transformers starts with the disconnecting procedure, which has to follow the local safety, rules for work on electrical equipment as well as (if available) the instructions of the manufacturer. Before any activity on the transformer can start it must be ensured that it has been switched off on the high- as well as the low voltage side, that the in- and out-coming lines are short circuited, safely and visibly earthed at the working place and that the operating panel of the circuit breaker and the low voltage power switchers are marked with a clear visible sign «do not switch works ahead». Furthermore, it must be ensured that access to the transformer is possible without any remaining risk.

The working area should be fenced off to avoid unauthorized access. A fire extinguisher must be positioned in a suitable place on site, ready to use in case of a fire hazard.

First of all inspect the transformer accurately on damage and leakage, then to avoid any further cross contamination it is, in case of leakages, essential to seal the leaking spots e.g. with SEDIMIT. Furthermore, remove all visible pollution on the metal parts e.g. with acetone to enable safe handling of the transformer afterwards.

Secondly it is, to avoid any risk of loss of PCB containing cooling fluid during dismantling and transport, advisable to drain the transformer on its location beforehand according to a well prepared work schedule and provision of all necessary equipment as PCB pumps, drums, personal protective equipment and tools. This procedure has also the advantage that it reduces the total weight of the transformer during transport considerably.

Before draining the oil, precautions for a spill have to be taken by covering the ground with one or two layers of extra strong plastic tarp and drip trays under the crucial parts like the oil pump, hose joints, etc. It is also advisable to have absorbents like sand, cement, or sawdust ready.

Due to the viscosity of the (pure) PCB cooling fluid, it might be difficult to open the drain tap. This has to be considered in advance to find the best possible solution. In case it is not possible to open the tap, drain the transformer via the oil filling cap or by removal of an insulator.

Picture 53: Draining of a PCB transformer

Picture 54: Phase out of an intact PCB transformer

Before the transformer is entirely drained off, it should be positioned at an angle to pump off as much cooling fluid as possible. It must be considered that there will remain some kilos of oil in the transformer after the draining off, which will be sweat out from the windings in time. The drain tap must be closed after the draining activities and, if possible, the transformer should be filled with an absorbent or some sawdust to bind the remaining PCB oil.

After removal of the device from its enclosure, investigate the area visually and decontaminate the floor, trench covers, walls and cables if necessary before installation of a new transformer.

If a transformer is free from damage and has no leakage and a clean surface, and the drainage is not performed on site, then the removal can be done in normal working overalls. Filling the same drum with PCB contaminated oil from different transformers is allowed if their PCB content is known and of a similar concentration. If no information about the PCB content of the oil is available, the oil must be considered as PCB contaminated and the drums with the unidentified oil have to be marked as PCB contaminated.

All persons assigned to handle PCB equipment should be thoroughly instructed in the proposed procedures, particularly with respect to safety precautions, the use of safety equipment and the applicability of national regulations.

Wherever possible, PCB liquids should be transferred by pumping to minimize splashing and spillage. Centrifugal-type pumps, having all wetted surfaces made of stainless steel should be used. The shaft seal should be an external carbon ring type to eliminate exposure of the packing material to the deteriorating effects of PCBs. Valves should be brass or stainless-steel lined. Hoses should be flexible metal or lined with tetrafluorethylene or silicone polymers, and drip trays should be paces under all pumps, valves and hose couplings.

7.2 Phase Out of Capacitors

7.2.1 Preparation

The phase out of capacitors starts with the disconnecting procedure, which has to follow the applicable safety, rules for work on electrical equipment as well as manufacturer's instructions. Before working on a capacitor or capacitor bank, the following operations must be carried out:

- Ensure that the circuit breaker or power switch and eventual line isolators for the affected capacitor are open and marked with a sign «do not switch works ahead»
- Short-circuit the incoming lines for the capacitor at the earliest 10 minutes after switch off.
- For high voltage capacitor banks connect earthing rods for each rack to the ground circuit by means of braids.
- Most capacitors are equipped with discharge resistors. Nevertheless, the terminals of the capacitor cases have to be shortened before any work is carried out on them, because the discharging circuits may be damaged.

The working area has to be fenced off by red/white plastic bands to avoid unauthorized access. A fire extinguisher has to be positioned, ready to use in case of a fire hazard.

Before the dismantling, it has to be checked if capacitors are leaking or if they are damaged. Leaks have to be sealed. Contaminated surfaces have then to be cleaned with e.g. rugs and acetone solvent. Puddles of PCB containing dielectric have to be sucked up by pumps or soaked up by adsorbents. All arising waste has to be collected and disposed of as hazardous waste.

Picture 55: Dismantling of capacitor battery

Picture 56: Inventoried and labelled capacitor

If spills are situated in areas where workers have to enter during the dismantling activities, these areas must be covered with oil absorbent carpet to prevent an entrainment of the contamination by the sole of the rubber boots.

Before packing any UN-approved drum with waste, the drums must be checked (damage, leaks, UN approval).

7.2.2 Dismantling

While dismantling the capacitors, the bushings must be regarded as the «weakest» parts of the capacitors. Especially for heavy capacitors, it is not allowed to hold on to the bushings while carrying them, as they might loosen or break off and cause a spill of PCB-containing fluid. The capacitors must be safely packed into UN-approved steel drums on site.

If capacitors have to be stored temporarily, they have to be placed standing upright (bushings up). It is recommended to place them into steel trays or, if not available, on oil absorbing carpets to prevent any spills.

7.2.3 Phase Out of Other Equipment

Other electrical devices like circuit breakers mostly contain small quantities of oil. After the phasing out of such equipment containing oil, it has to be checked e.g. with a suitable test kit if the cooling fluid is PCB contaminated. If the test kit shows a contamination of > 50 mg/kg the equipment must be considered as PCB contaminated and disposed as hazardous waste.

Picture 57: Bad example of packing and storage

Picture 58: Packing of leaking caps into UN drums

PACKING

If there are no specific or sufficient national regulations referring to packaging, storage or transport of PCB, the international regulations shall apply.

Transport and packing of dangerous goods are regulated by various international regulations. There is a separate regulation for each means of transport (road, rail, sea) as you may see in chapter 10.1. The packing instructions are very similar to each other. The specifications of the different packaging types for PCB containing material according to the ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road) are mentioned below:

8.1 Packing According to ADR

Due to the easy handling, open head steel drums are usually used for solids and tight head steel drums for liquids, respectively.

Table 16: Packaging types

Packaging Type	Purpose	Packaging Type Code
Tight head steel drum	Liquids	1A1*
Open head steel drum	Solids	1A2*

* Explanation of packaging type codes:

The maximum volume authorized by the ADR is 450 litres. However, drums with a volume of 220 litres are easier and safer to handle and therefore usually chosen.

In addition, a volume of 220 litres is also permitted for a transport by sea (IMDG limit for liquid PCB: 250 litres).

Picture 59: Open head drum

Picture 60: In print UN approval

Packaging must conform to the construction and testing instructions stipulated in the ADR regulations. Strength and tightness are tested. UN approved steel drums have an imprint to prove a successful testing.

For the transport of PCB containing capacitors, the code can read as follows:

UN 1A2 Y 400 03 CH2025, meaning:

In case of liquid PCB, drums must never be completely filled. Approx. 50 mm or 10 % of the volume should be left empty for a possible extension of PCB in case of higher temperatures. Pumps should be used to fill the drums; pouring the liquid from one drum into another is no viable option. As disposal prices and techniques depend on the kind of waste, liquid and solid wastes should always be separated.

Table 17: Code for UN approved drums

UN	Symbol of the United Nations or the letters UN
1A2	Code for packaging type
Y	Two-part code: Letters of packaging group
400	For solids: Maximum gross weight in kg (example)
03	The last two figures of the year of manufacture (example)
CH2025	Manufacturer's code (example)

The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) was done at Geneva on 30 September 1957 under the auspices of the United Nations Economic Commission for Europe, and it entered into force on 29 January 1968. The Agreement itself was amended by the Protocol amending article 14 (3) done at New York on 21 August 1975, which entered into force on 19 April 1985.

The Agreement itself is short and simple. The key article is the second, which says that apart from some excessively dangerous goods, other dangerous goods may be transported internationally in road vehicles subject to compliance with:

- the conditions laid down in Annex A for the goods in question, in particular as regards their packaging and labelling; and
- the conditions laid down in Annex B, in particular as regards the construction, equipment and operation of the vehicle transporting the goods in question.

Annexes A and B have been regularly amended and updated since the entry into force of ADR. The last amendments entered into force on 1 January 2007, and consequently, a revised consolidated version was published as document ECE/TRANS/185, Vol. I and II («ADR 2007»).

Annex A: General provisions and provisions concerning dangerous articles and substances

Part 1: General provisions

Part 2: Classification

Part 3: Dangerous goods list, special provisions and exemptions related to dangerous goods packed in limited quantities

Part 4: Packing and tank provisions

Part 5: Consignment procedures

Part 6: Requirements for the construction and testing of packaging, intermediate bulk containers (IBCs), large packaging and tanks

Part 7: Provisions concerning the conditions of carriage, loading, unloading and handling

Annex B: Provisions concerning transport equipment and transport operations

Part 8: Requirements for vehicle crews, equipment, operation and documentation

Part 9: Requirements concerning the construction and approval of vehicles

8.2 Summary of Possible Containers for PCB Transports

Apart from the commonly used steel drums, also other packaging types can be used, as long as they are UN approved and comply with the instructions of the ADR for the transport of the goods.

UN approved drums or containers should only be procured from an authorized manufacturer (ask for UN Certificate).

Table 18: Summary packaging

Packaging		
Waste Type	**Containers**	**Dimensions**
PCB liquids	UN approved steel drums for liquids 1A1 Large packaging IBC, 31A., 31B, 31N Tank Containers	60 to 220 liters 500 to 1250 liters Various sizes
PCB capacitors	UN approved steel drums for solids 1A2	Usually 220 liters
PCB transformers (only when drained!)	Steel trays 20' Box Containers with tip tray	Height over 800 mm Various
PCB solids, (metals, soil, debris)	UN approved steel drums for solids 1A2	Usually 220 liters
Damaged packaging (e.g.220 liters steel drums)	Recovery drums Various types	Recovery drums Various types 307 liter und 427 liter

There are many different types of UN-approved packaging available. The choice of the appropriate packaging depends on type of waste, quantity, mode of handling/ transportation but also foreseen method of disposal/treatment. For contaminated soil it might be advisable to use UN-approved Big Bags.

Picture 61: UN approved steel drums

Picture 62: Different types of alternative PE packaging

As described, UN approved steel drums have an imprint to prove a successful testing. Where an imprint is not possible, the containers must have an UN approval plate stating conformity to UN regulations.

Picture 63: Example of UN approval plate

Due to safety and handling reasons, however, PCB wastes should ideally be packed into UN approved steel drums. For example, capacitors shall be packed into UN approved drums (1A2). In the drum, they must always be stored standing upright. Any moving of the waste inside the drum has to be avoided, i.e. by using absorbents, wood, rugs, etc.

Special bulk containers can be used for the storage or transport of PCB containing or contaminated solids as long as they conform to UN standards. A respective UN approval plate must be affixed to such bulk containers.

Picture 64: UN approved ICB solids

Picture 65: UN approved IBC liquids

Picture 66: 20' tank container liquids

Picture 67: Phase out and cleaning of PCB capacitor

Picture 68: PCB capacitors in steel drum

Special attention is needed during dismantling and packing of leaking PCB containing capacitors. The main aim shall be to avoid cross contamination. Therefore immediately after phase out of the capacitors, the devices need to be placed in a drip tray. The surface should be cleaned and if necessary a leakage stop device can be used. When packing capacitors an appropriate part of the area shall be covered with e.g. chemical absorbing industrial carpet, an oil absorbent sheet or other suitable materials, in order to protect it from cross contamination or incidents during the packing procedure.

The lid should be removed from an empty drum and the drum carefully checked for damages as also new drums could be punctured due to careless handling. Ideally, PE-LD drum inlets are first placed in the drums. Then a thin layer of oil absorbent (e.g. absorbent material) should be placed in the drum. The PCB containing capacitors can then be carefully placed in the drum. As many capacitors as space allows may be placed in a drum. Ideally, appropriate material like Styrofoam should be placed between and around the single devices so that movement during transport will not be possible. Of course, all this depends on the size of the electrical devices and is mainly for low and medium voltage capacitors. If the height of the capacitors exceeds the drum, it might be necessary to carefully break off the bushings. Such activities shall only be allowed after the capacitors have been put into drums. Capacitors already placed in drums (upright position), but showing leaking isolators, do not pose a risk. Additionally, a layer of sawdust should be placed in each drum, in order to absorb any liquids if necessary.

According to today's regulations, unpackaged transformers and capacitors may be carried in cargo transport units fitted with a leak proof steel tray, having a volume of at least 125 % of the remaining PCB liquid in the transformer and a height of at least 800 mm, and containing sufficient inert absorbent material to absorb at least 1.1 times the volume of any free liquid.

Picture 69: Preparation: transportation of PCB transformer

Picture 70: Covering the bottom with absorbent material

Adequate provisions shall be taken to seal the transformers and capacitors to prevent leakage during normal conditions of carriage.

Due to their size, transformers cannot normally be packed in boxes or even drums. Therefore, they have to be prepared and loaded on trucks in such a way, that no contamination of the surrounding materials is possible. Precautions have to be taken to prevent leakage and secure the devices.

Picture 71: Loading of transformers

Picture 72: Stowing of transformers

Due to safety reasons, UN approved drums or alternatively UN approved boxes, should be used, whenever possible.

Picture 73: Example of alternative metal boxes

Picture 74: Further alternative metal boxes

Damaged or leaking drums as well as drums that do not conform with the regulations must be stored and transported in recovery drums. Appropriate measures must be taken to prevent movements of the inner drum.

If the recovery drum carries liquid PCB, a sufficient quantity of absorbing material should be added to immediately absorb possible liquid coming out of the inner drum.

Picture 75: Recovery drum I

Picture 76: Recovery drum II

Picture 77: Plastic recovery drum

8.2.1 Labelling of the Packaging

The labels identify the dangers posed by the packed goods and is destined to attract the attention of the person handling the goods to take the necessary precautions during storage or transport.

The «Orange Book» defines the identification of a hazardous material or article. These assigned identification numbers are also generally referred to as «UN numbers».

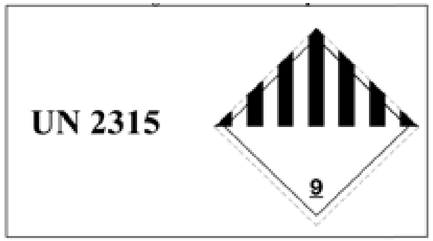
Table 19: UN numbers for PCB

UN 2315	Polychlorinated biphenyls, liquid
UN 3151	Polyhalogenated biphenyls, liquid or Polyhalogenated terphenyls liquid
UN 3152	Polyhalogenated biphenyls, solid or Polyhalogenated terphenyls solid
UN 3432	Polychlorinated biphenyls, solid

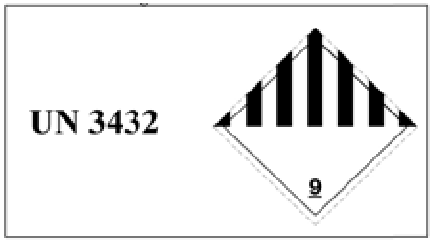
8.2.2 Labelling for Storage or Transport

If waste is transported by road (ADR), each packaging must be marked clearly and durably with the UN number of the contained goods, the letters "UN" coming first. A label of class 9 "Miscellaneous dangerous substances and articles" must be affixed to each packaging (see Picture 78 and Picture 79). In case of recovery drums, the designation «OVERPACK» must be added.

Remark: The class 9 pictogram is included in the UN Model Regulations but has not been incorporated into the GHS because of the nature of the hazards. In the GHS system the nature of hazards has been defined in such a way that various class 9 materials are included in other more specific classes. Nevertheless, the transport labels are still the same as in the Dangerous Goods transport regulations. GHS only concerns the packaging of materials and concerning waste there are some exemptions, in other words, less stringent definitions concerning the exact composition of materials. Consequently, class 9 is used when transporting PCBs.



Picture 78: Labeling Acc. to ADR for liquid PCB

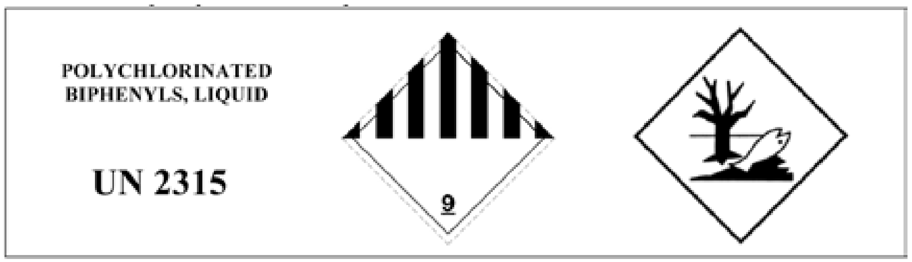


Picture 79: Labeling Acc. to ADR for solid PCB

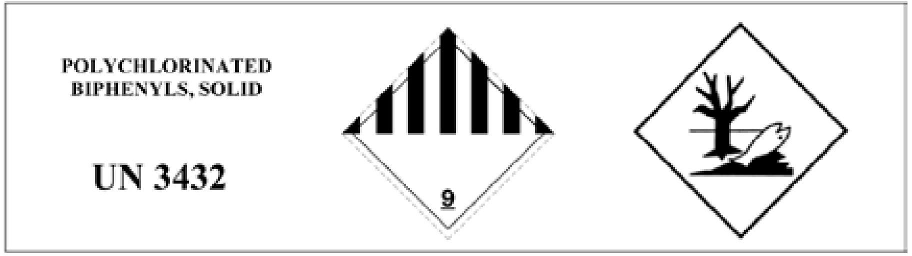
The UN number for PCB capacitors is UN 2315.

The identification of containers for a transport by sea is different. The IMDG (International Maritime Dangerous Goods Code) applies for such shipments.

In addition to the UN number, the proper shipping name (PCB) must be mentioned and some indication about the condition of the contents (LIQUID or SOLID) must be made. The class 9 label as well as a marine pollutant label must be affixed on the containers. Since 2009 a new marine pollutant label shows a dead tree and dead fish.



Picture 80: Labelling of liquid PCB according to IMDG



Picture 81: Labelling of solid PCB according to IMDG

The weatherproof drum/container labels should at least contain the following data:

- UN number
- UN classification
- "HAZARDOUS WASTES"
- Waste identification code
- Waste designation
- Tracking form number

Additionally it is advisable to add the following:

- Origin of the wastes
- Weight of the drum
- Drum tracking number

8.3 Handling of Packed Waste

It is essential to weigh the packed drums. If possible a mobile scale can be used on site. This allows a reliable planning of the transport of the waste. The following information shall be additionally written clearly on the lid of the drum:

- Contents
- Name of the location, where the packed goods originate from
- Date
- Weight and signature

The drums with open lid must be secured by «splints». Full drums should preferably

Examples of labels to be used for PCB waste declaration:

Picture 82: Safety Drum lift

Picture 83: Marking the drums

be carried by a safety drum lift, forklift or crane. If using a crane, there are special drum clamps available for safe handling. Only checked and clean drums shall leave for disposal respectively to the temporary storage area.

Packaging depends on type of waste, waste quantity, mode of transport and method of treatment or disposal. Further details are mentioned in chapter 8.2.

TEMPORARY STORAGE

9.1 Temporary Storage - On Site

PCB containing wastes should generally not be stored on sites that are not specifically designed for interim storage of hazardous wastes. Usually, there is no appropriate infrastructure to guarantee a safe storage. Uncontrolled and inexpert interim storages as shown in the pictures below endanger people and the environment, and result in unnecessary additional costs.

Picture 84: Bad example I (open air storage)

Picture 85: Bad example II (no tip trays)

PCB containing devices should be packed safely and in compliance with the applicable laws (see chapter 8.1.) as soon as they have been phased out, even if their disposal takes place at a later stage. Irrespective of the quality of the temporary storage, the final and environmental sound disposal of the waste must be scheduled and coordinated so that storage will not exceed twelve months. Generally, electrical equipment should only be phased out and stored, once an appropriate method of disposal has been chosen.

When setting up a temporary storage for PCB wastes it is important to choose an appropriate storage area. Locations close to rivers, groundwater, residential or farming areas, and ecological reserves or for example food processing industries CANNOT be considered suitable. If possible, the interim storage should be specifically designed for PCB containing equipment and wastes.

Table 20: Minimum requirements for temporary storage on site

Packing

- Capacitors must always stand upright. The insulators are the weakest parts. Never lift a capacitor by holding the insulators, they can easily break off.
- Capacitors must be stored on steel drip trays and leaking devices should be sealed. It is advisable to add absorbents to the steel trays.
- It is possible to put capacitors and contaminated solids into containers that are not UN approved. However, such containers must be checked for damage and leaks before use and cannot be utilized for transports. After use, the containers must be regarded as contaminated and also be disposed of as hazardous waste!

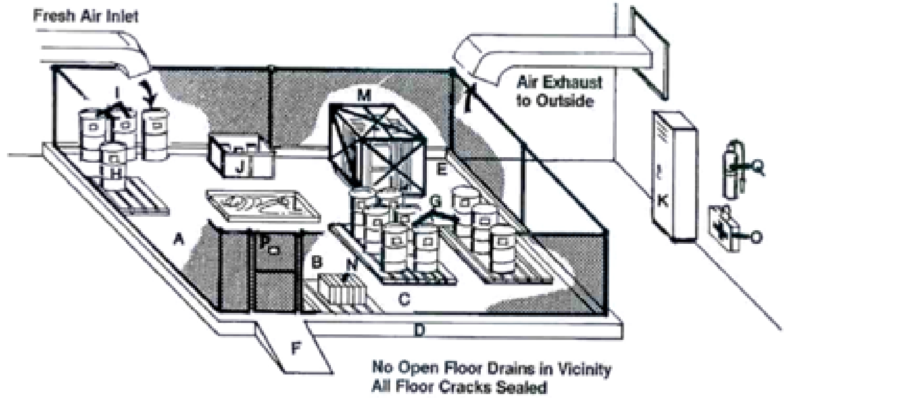
Building

- The floor of a temporary storage must be solid and tight. The storage must be walled and protected against the weather on all sides.
- All entrances to the storage must be marked with an appropriate warning, and access for unauthorized people must be forbidden.
- The area must be fenced and controlled.
- Display emergency procedures and best working practices (see Annexes 12.8 and 12.9).
- The building should have some openings for permanent ventilation (ventilation systems with filters).
- Increased risks of fires must be excluded (no wooden shed, no storage of inflammable goods in the same building or in the neighbourhood). A smoke and fire alarm system should be installed.
- Fire extinguishers (powder) and absorbents (e.g. sawdust) must be available and easy accessible.
- The building should be separated in different areas (reception, handling, separate storage of different waste categories, equipment, etc.)
- No food storage or food processing companies in the neighbourhood.

All goods/wastes must be clearly marked giving information about the kind of waste, the date of packing, the weight, the origin and further important data. An up to date storage list must be accessible at any time.

Temporary storage CANNOT be accepted as long-term solution.

Picture 86: Example 1 of a sound storage platform [Source: unknown]



Legend

A - security fence
B - padlocked door
C - concrete floor (no drains)
- all cracks and expansion joints between slabs sealed with compound
- floor painted with epoxy paint to prevent PCBs to penetrate in concrete
D - concrete curb around perimeter of storage area; inside of curb painted with epoxy
E - sealing compound (grouting) at corner of curb to prevent leakage under curb
F - ramp over concrete curb, into storage area
G - drums containing PCB-wastes
- stored on pallets for mobility
H - recovery drum
I - spare drum
J - clean-up materials, stored in bin
K - locker for PPE worn when working with PCBs
L - pumps and hoses for use with PCBs laid in a drip tray
M - scrapped transformer in protective crate
N - delivered capacitors on pallets for packing
O - first-aid kit
P - PCB label on door
Q - powder or foam-type fire extinguisher

9.2 Central Storage Platform

A central storage platform shall provide the necessary storage room, where PCB devices and associated waste can be collected and stored until their final disposal. Such a platform could also be used as a «buffer zone» by regional or national authorities, or by waste treatment / disposal plants to guarantee a constant running of their plants.

PCB equipment and PCB wastes shall be stored according to their category or priority. Appropriate areas shall be defined for each type/ category of PCB waste. Ideally, already existing storage facilities, for example the facilities of PCB equipment holders could be upgraded to meet safe and professional standards.

Available Site

The available site must be carefully monitored and reported in respect of existing groundwater and its level, existing soil contaminations as well as permeability of underground. The most suitable location shall be defined under consideration of the following criteria.

- The storage building shall be located and maintained in conditions that will minimize volatilization, including cool temperatures, reflective roofs and sidings, shaded location, etc.
- The surrounding land should be sloped to provide drainage away from the site
- The area must be fenced and controlled
- All entrances to the storage platform must be marked with appropriate warnings
- An access control system shall be installed to ensure access of authorized staff only

Human and Environmental Hazards

PCB belongs to the group of POPs banned by the Stockholm Convention. Therefore all relevant precautions must be provided to avoid human and environmental hazards. The entire interim storage facility must meet BAT and BEP requirements.

Technical Hazards

The whole area used by the interim storage facility must be protected against spillage of contaminated oil and of chemicals.

Area Preparation

- Wherever necessary, the ground must be sealed with adequate material, considering PCB but also associated solvents and chemicals when handling and treating PCB containing electrical equipment and oil. The sealed area must be dewatered with special sewers, capable for retaining any oils and other insoluble organics.
- Due to the possibility of fire hazards efficient fire protection and firefighting equipment must be provided. In combination with the firefighting equipment an appropriate collecting volume for effluent water must be provided.

Logistics

- The existing transport infrastructure to and from the area (road and railways) shall be used for the proposed storage facilities.
- The building shall be accessible by forklifts and trucks.
- There should be enough space for any truck or crane movement in front of the building. This central receiving area where PCB equipment and wastes are loaded and unloaded from transport vehicles should have a PCB impervious floor and containment system to properly control any spills during loading or unloading.

Handling of Incoming Goods

- Each incoming waste delivery shall be examined and checked as follows:
  - Internal information and weighing
  - Check of accompanying tracking forms/ sheets, sampling and visual check of wastes
  - If necessary, screening of waste sample
  - Labelling and storage at defined storage area, according to waste category
- Only equipment accompanied by duly signed tracking forms/sheets shall be accepted and stored in the interim storage. Tracking of the waste generator must be ensured at any time.
- Transformers for dismantling or revision, delivered by rail or road transport must be kept in a covered and spillage protected area until they are tested for contamination with PCB. After testing they shall be stored inside the storage building in separate compartments for contaminated and not contaminated units. If ever possible, the transformers shall be stored on racks mounted on drain trays. But if stored on racks or not, all units must be placed in such drain trays.
- Handling equipment like overhead cranes and forklifts for all kind of transformers shall be provided.
- Every container with transformer oil, which is present in the intermediate storage facility must be tested, labelled and stored in compartments according to their contamination.

Capacity

- There shall be an intermediate storage in a suitable size for the needs of the area/region. It is recommended to store as a maximum 25 transformers in sizes of 200 to 1’500 kVA as well as boxes and drums with some 150 to 200 tons of PCB waste.
- These maximum capacity restrictions shall assist in keeping the intermediate storage platforms real temporary and no long-term solution storages.
- Capacitors and wastes which cannot be treated shall be shipped to a licensed disposal facility within Europe on a periodical basis.
- PCB wastes shall be packed in accordance with the instructions stipulated in the ADR, RID and in some cases also according to IATA.

Foundation

- The storage building must contain a foundation suitable for mounting metal sheet walls and roof as well as piles designed to support overhead cranes for the handling of the delivered transformers.
- All structures above ground level must be coated and sealed like the floor.

Floor

- The floor profile must be shaped in a way that no spillage from transformer handling or effluent from firefighting may flow outside the facility into the unprotected area.
- All floors inside the storage building must be industrial type floors (e.g. steel or concrete) and sealed with a PCB resistant sealant such as two-component epoxy paint.
- It is recommended that the sealant coating is inspected periodically to check its integrity.
- The building shall be set on asphalt or concrete.
- The floor inside the building shall be concrete; coated with a durable epoxy polymer to prevent PCBs to penetrate in concrete.
- The floor must be solid and tight, all cracks and expansion joints between slabs must be sealed.
- Floor drains shall be reduced to a minimum and must be connected with an internal sump.

Curbs

- The storage area for transformers within the intermediate storage shall contain 6 inch high curbs that provide a containment volume equal to at least twice the internal volume of the largest PCB item.
- Concrete curb around perimeter of storage area; inside of curb painted with epoxy. Sealing compound (grouting) at corner of curb to prevent leakage under curb.
- The storage building may not have any openings, expansion joints or drains that would permit liquids to flow from the curbed area.
- A ramp over the surrounding concrete curb shall be provided to allow access with forklifts into the storage and handling area.

Walls, Doors and Windows

- The walls of the storage building may consist of a light metal sheet construction. Doors and windows have to be foreseen according to the requirements of the user, logistics and treatment process.
- Doors must open to the outside. Minimum width for any door is 80 cm.
- Windows must be planned and built in such a way that they face each other.

Roofing

- In order to prevent the atmosphere in the storage building from extended temperatures (vapour pressure of PCB!) the roof shall be reflective.
- The roofs of the building shall be sloped so as to provide drainage away from the site.

Layout of the building

The building shall be separated in different areas:

- Reception area
- Handling area
- Treatment area
- Separate storage areas or rooms for each type of PCB waste:
  - PCB containing transformers
  - PCB containing capacitors
  - Drums with PCB oil
  - PCB solid wastes
- Equipment area
- Office
- Sanitary installations

There must be a fairly big working area, where e.g. transformers can be drained or waste handled and packed. The floor of this area should be preferably covered by steel (like a drip tray) and absolutely tight, optionally, a special, PCB resistant epoxy coating could be applied.

PCB wastes should be packed as to ensure that the potential for leakage or spills is kept to a minimum (e.g. in UN approved drums). The containers should be clearly labelled and marked with the date of entry to the storage. Drums or other portable containers of PCB and PCB equipment should be placed on pallets.

Sufficient space should be left between stored containers and equipment to permit inspection and allow the safe movement of vehicles such as forklifts. Drums or other containers of PCB liquids should be separated from each other by pallets and not stacked more than two containers high.

Ventilation

- A ventilation of the entire storage facility must be installed to avoid elevated concentrations in the atmosphere of PCB and other POPs which might be present. Generally the exhausted air must be cleaned by activated carbon filters. If necessary, the ventilation must be supported by an induced draft fan.
- A fresh air inlet shall be installed in accordance to induced draft fan specification. If there is no specific legislative requirement a guideline will be a twofold to sixfold air volume exchange during normal operation with the possibility to increase to tenfold or twelvefold in case of high gas concentration alarm.

Fire alarm / Fire protection

- Due to the extreme environmental and health hazards in case of a fire in the storage building, it is very important that a smoke- and fire alarm system covering the entire facility will be installed.
- The detection-, alarm- and fighting system must meet all relevant national and community regulations as well as international BAT and BEP standards.
- The building shall have a fire suppression system; preferably a non-water system. If the fire suppressant is water then the floor of the storage room shall be curbed and the floor drainage system must not lead to the sewer or storm-sewer or directly to surface water but should have its own collection system such as a sump.
- Fire extinguishers (powder) and absorbents (e.g. sawdust) must be available and easily accessible.
- A lightning protection system covering the whole interim storage facility must be installed.

Electrical Installations

- All the electrical installations must be installed at least 1.5 meters above ground level to assure a certain protection against explosion risks.

- The quantity and design of electrical connectors shall be defined in cooperation with the operator of the waste preparation units.

Installations for control of water run-offs

- The sumps within the protected area shall contain a level alarm high and high+.
- Water run-offs and canals must be leak-proof and easily accessible for cleaning purposes.

Pipelines

- Any pipeline to be installed in the interim storage facility must be over ground.

Emergency equipment

- All the necessary emergency equipment for a safe shut down of the plant and all necessary equipment for a safe and controlled evacuation of the storage facility in case of fire must be available and easily accessible.

Emergency response plan

- Emergency procedures and best working practices shall be displayed.

Health and safety plan

- A health and safety plan shall be displayed.

Spill prevention, control and countermeasure plan (SPCC)

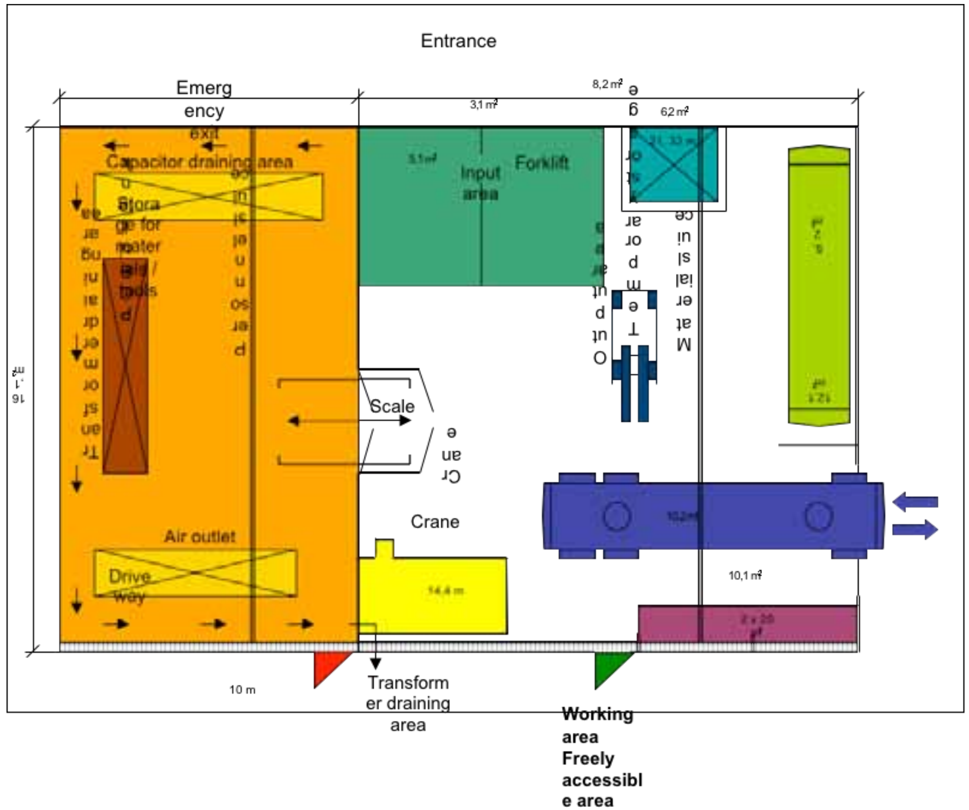
- The site should be subjected to monthly inspections for leaks, degradation of container materials, floors, drains, draining systems, personal protection equipment, integrity of fire alarms and fire suppression systems, vandalism, security fences and general status of the site.

Database of Interim Storage Platform

- A complete database of the PCB wastes and other equipment and chemicals in the storage site shall be created and kept up to date as waste is added or disposed of. The records should include:
  - An inventory of each item of PCB waste and the quantity of PCB therein
  - The date and source of PCB waste transferred to storage and the date and destination of waste leaving storage
  - A description of the PCB waste including the quantity and concentration of PCBs, nameplate description where available
  - Identification number for the PCB waste
  - Name of carrier of PCB waste
  - Name of recipient of PCB waste
  - Date and quantity of PCBs spilled as a result of a leak or accident and clean-up procedures adopted
  - Dates and details of inspections by the competent authorities and the owner
  - The responsible fire brigades and environmental authorities shall be informed about the amount of PCB wastes in stock periodically (e.g. every 2 weeks), by providing them with a copy of the latest stock list/records.

Personnel working at the facility should be made clearly aware of and understand current PCB waste management procedures including the use of personal protection equipment and clean-up techniques.

The above inputs shall be taken as general advice and recommendation. However it is important to review them at the time of construction or upgrading of an existing storage facility together with the competent local and governmental authorities as regulations and guidance may change.



Picture 87: Example 2 of a sound storage platform

If there is neither a storage platform as previously described nor another possible interim storage building, a kind of mobile interim storage could be installed for short-term use. Depending on the quantity of the arising waste, 20' or 40' Box Containers with integrated drip trays as safety precaution could be an option.

Picture 88: Typical 20' Box Container with trip tray

Picture 89: Short term storage in containers

It should be considered that usual Box Containers do not contain a steel ground but only wood and therefore need to be adopted.

9.3 Authorization and Control

The establishment of an interim storage facility or a central storage area is only possible after submission of an Environmental Impact Assessment study and is subject to authorization of the competent authorities.

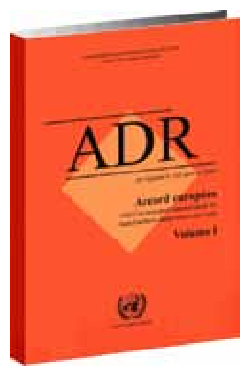
It is further recommended that an extension of temporary storage beyond the period of 12 months shall also be subject to authorization by the competent authorities.

TRANSPORT

10.1 International Regulations for the Transport of Hazardous Goods

Depending on the means of transport for hazardous goods, the following regulations are applicable:

- ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road)
- IMDG (International Maritime Dangerous Goods code/transport by sea)
- RID (Regulation for the international transport of hazardous goods on railways)
- IATA DGR (IATA regulations on the transport of hazardous goods/air transport)
- United Nations Recommendations on the Transport of Dangerous Goods Model Regulations (Orange Book)



Picture 90: ADR

Picture 91: IMDG

It should be noted that various regulations (ADR/IMDG/RID/IATA-DGR) are substantially similar to one another. The only difference is that special packaging, labels or quantity limits are specified for the different means of transport, depending on the type of hazardous goods.

ADR

10.2 Obligations of Main Actors

Basically, the ADR distinguishes between three main actors, whose obligations are described as follows:

Exporter

- To check if the goods to be transported are classified and approved for shipment.
- To supply all necessary transport documents.
- To only use UN approved packaging that are correctly marked and labeled.

Carrier
- To make sure that all necessary documents are carried along in the vehicle.
- To check if the freight is in good condition, i.e. no visible damages like leaks or cracks.
- To make sure that the vehicle is not overloaded.
- To make sure that the placards and labels are affixed.
- To make sure that the equipment as stipulated in the written instructions for the driver are carried along in the vehicle.
- Not to transport the freight if it does not comply with the regulations.

Importer
- Not to delay the acceptance of the goods without compelling reason, and to check after the unloading if the ADR instructions concerning the import are fulfilled.
- To clean and decontaminate vehicles and containers.
- To make sure that any labels, marks and signs are no longer visible on the completely unloaded, cleaned and decontaminated container.

10.2.2 Documentation
The following documents must accompany every shipment in accordance with the ADR:

Movement document
The following data of every single good/ waste must be mentioned on the movement document:
- UN number, with the letters «UN» in front of the number
- If the goods are wastes, the word «WASTE» must be written in front of the UN number
- The official designation (Polychlorinated Biphenyl) plus the technical term (PCB)
- UN class (9)
- Packaging group
- Packaging type and number of packaging
- Total quantity of each dangerous good with different UN number
- Name and address of exporter
- Name and address of importer

Container packing certificates
If dangerous goods are transported in box containers by sea, a container packing certificate must be enclosed to the movement document. Basically, the container packing certificate confirms that the goods have been packed and loaded according to paragraph 5.4.2 of the IMDG Code. The container packing certificate can be integrated in the movement document. An example is shown in Annex 12.19.

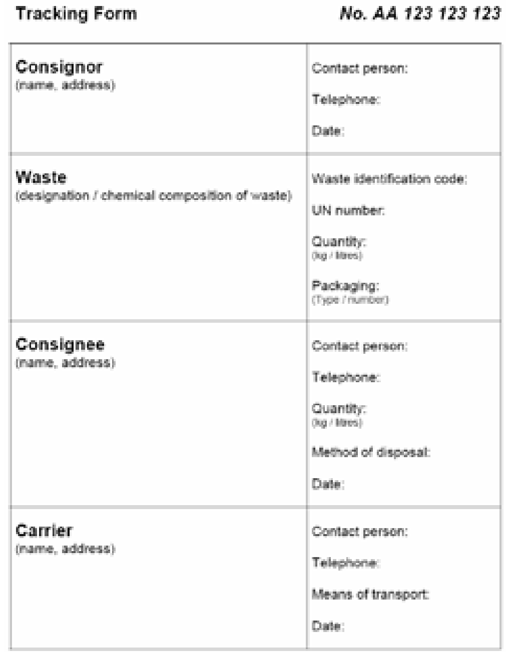
Written instructions
To be able to take actions immediately in case of an accident or an incident, the driver must be provided with transport emergency cards for each transported dangerous good briefly informing about the following:

- Designation, class and UN number
- Possible dangers that can be posed by the goods
- Necessary additional equipment
- Measures to be taken

Not only ADR regulations but also Basel Convention procedures and documents must be considered for international transports of hazardous wastes. The two regulations sometimes overlap and it is e.g. sufficient to use the Basel Convention Movement Document (see Annex 12.18.) to accompany the transport.

10.3 National Transports
National transports of PCBs and PCB wastes have to be in accordance with the national hazardous goods regulations and laws.

If necessary, national legislation to regulate criteria for the transport of hazardous wastes, such as insurance, registration and license and safety aspects, shall be developed.
Also during national transport a movement document shall accompany the wastes at any time.


Tracking Form No. AA 123 123 123

Consignor (name, address)	Contact person: Telephone: Date:
Waste (designation / chemical composition of waste)	Waste identification code: UN number: Quantity: (kg / litres) Packaging: (Type / number)
Consignee (name, address)	Contact person: Telephone: Quantity: (kg / litres) Method of disposal: Date:
Carrier (name, address)	Contact person: Telephone: Means of transport: Date:

Picture 92: Example of possible nation tracking form

10.4 Transboundary Movement of Hazardous Waste
When exporting PCB wastes to other countries, the procedures stipulated by the Basel Convention (see chapter 1.2) have to be followed. One important condition under the Basel Convention is that a transboundary movement of hazardous wastes or other wastes can take place only upon prior written notification to the competent authorities of the States of export, import and transit, and upon

consent from these authorities permitting the transboundary movement of waste.

Furthermore each shipment of hazardous waste or other waste shall be accompanied by a movement document from the point at which a transboundary movement begins to the point of disposal (see Annex 12.8).

Please contact the competent national authority for specific information:

10.5 Loading and Safety Check before Transport Takes Place

The type of packaging and transport depends on the chosen method of disposal and may vary. It should be considered that beside the national and international packaging regulations also the disposal facility might have special specifications. No person shall handle, offer for transport or transport PCBs or devices containing PCBs, including waste, unless he is trained to do so, or is performing those activities under the direct supervision of a trained person.

10.5.1 Loading on a Truck for Local Transports

All hazardous wastes ready for transport have to be packed and labelled according to the ADR (see chapter 8.).

10.5.2 Loading of Containers for International Transport

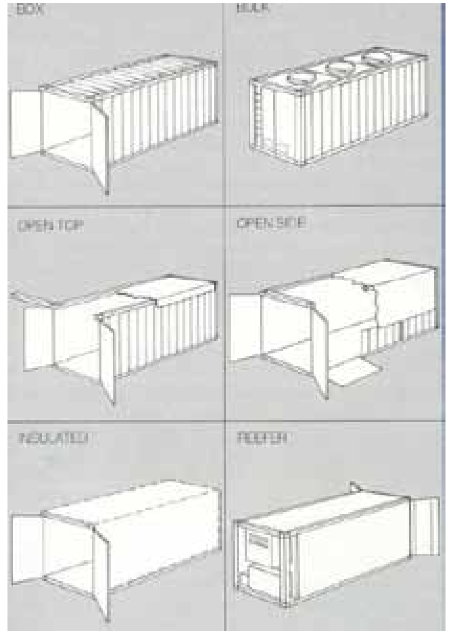
Due to safety reasons, it must be considered that PCB containing waste should be loaded at one go. Therefore, the loading of containers is performed shortly before their transport.

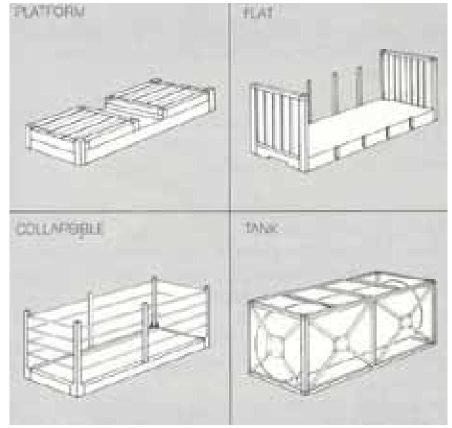
The containers have to undergo an examination by an accredited Customs Office. Before the containers are loaded, it is first necessary to check their condition again. Dust and dirt on the loading surface have to be removed.

Each single drum has to be checked for safety and possible damages. The drums have to be handled carefully. The code, content, number and weight of every loaded drum have to be recorded in a Container Loading List.

For the weighing activities a calibrated mobile scale has to be used. Only units that are given free from inspection and weighing may be loaded.

There are various types of Containers which can be used for the transport of hazardous wastes:

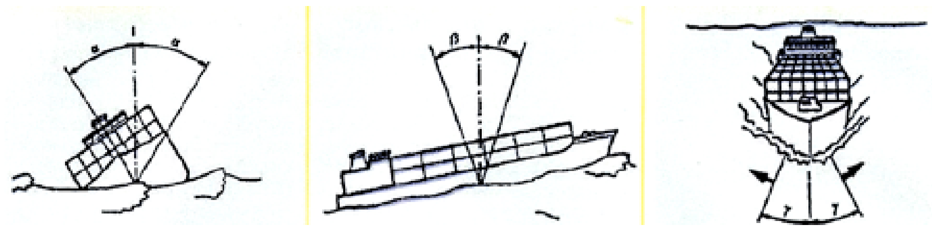




Picture 93: Different types of containers

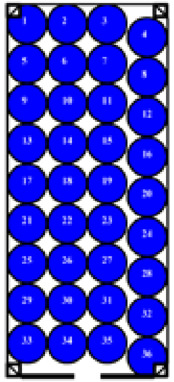
When wastes are transported over long distances, it is particularly important to ensure that the load cannot shift. The load can be ideally secured by optimal utilisation of space and by safety measures like tightening belts, antislip wooden boards and air bags. It is also necessary to ensure that the weight of the individual packaging in trucks or containers is evenly distributed.

Furthermore, the total gross loading weights, which vary from country to country, must be considered.

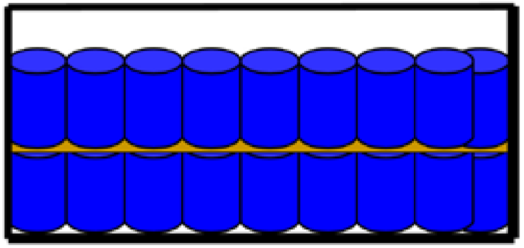


Picture 94: Movements of containers e. g. on ships to be considered

If 20' Box Containers will be used for transportation, there is space for 36 UN approved drums in one layer. The containers shall be loaded with two layers of drums, therefore a total of 72 drums may be loaded into one container. The next picture illustrates how the drums are loaded in the container with a floor between the layers, made of plywood planks.



Picture 95: Top View of loaded 20' box container



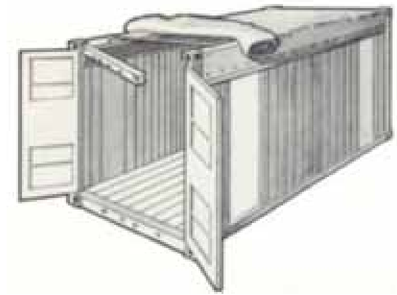
1st layer: 36 drums
2nd layer: 36 drums
Total: 72 drums per Container

Picture 96: Side view of loaded 20'box container

Picture 97: Loading of container

Picture 98: Lifting of containers to truck

When transporting (drained) transformers, the devices must be tightened by using sufficiently strong belts fixed to the lifting eyes. The loading is easier if open top containers are used. However, such containers must be covered by a tarpaulin to protect against the rain.



Picture 99: Open top container

Picture 100: Loading of transformers

There are also special containers for the safe transport of PCB containing transformers that have not been drained (see picture above). Such units, however, are rather expensive.

10.6 Waste Transportation by Air

Air transports of UN no. 2315 and 3432 are basically possible. However, IATA regulations do generally refer to substances in their original, pure form only, and NOT to wastes.

It is therefore not appropriate and not recommended to transport Hazardous Waste wastes by air.

In the frame of a GEF financed disposal project in Eastern Europe, PCB wastes were however transported by airplane to their final destination in Western Europe. The usual proceeding according to the Basel Convention was undertaken.

Picture 101: PCB waste ready to be transported by air

If this option is seriously considered by a country, detailed investigation with all competent authorities incl. IATA, have to be made.

Furthermore, specific packing instructions have to be followed. The staff in charge of packing, loading and shipping must have attended a special training, and they must have official permission to perform this task (specific approval).

PRE-TREATMENT, TREATMENT AND DISPOSAL

To select the most appropriate technology several rateable and non-rateable criteria have to be considered. Among "non-rateable", or relative criteria, are included public acceptability, risk and environmental impacts, which depend on the specific geographic site location. The rateable criteria may include the applicability of the method (in accordance with its development status), BAT and BEP, already approved technologies, overall cost, resources, minimum achievable concentration, clean-up time required, reliability, maintenance, post treatment cost and ability to use soil after treatment. Furthermore, an Environmental Impact Assessment study shall be carried out to evaluate a technology.

An important requirement of a professional PCBs disposal technology is the destruction efficiency greater than 99.99%. Destruction efficiency (DE) is defined as the total mass of a chemical into a process, minus the mass of the chemical in all products, by-products and environmental releases, divided by the input mass (to give a percentage). This may differ significantly from the other common measure, destruction and removal efficiency (DRE) which only takes into account stack emissions; with no regard for other releases and residues. A process must be able to handle upsets, such as power supply failure, without danger to personnel or equipment. Handling and loading of POPs into the process must always be safe, straightforward and controlled. Equipment and controls must be simple and robust, and will preferably make use of local resources. The operating procedure must be extremely basic and virtually fail-safe. Loading and unloading, start up and shut down must all be straightforward.

The difference between technologies that only separate and/or concentrate a pollutant (e.g. solvent extractions, thermal desorption) and those which destroy the contaminant (e.g. incineration, dechlorination or biodegradation) must be considered. Those technologies that only immobilize contaminants (e.g. landfill systems, stabilization and vitrification) should also be clearly differentiated.

11.1 Technologies and Methods in General

The technologies listed below and presented more in detail in Annexes 12-3 and 12.6 cover a wide range of degree of treatment and recovery of transformer components, a factor which must be taken into account in comparing technologies. Decontamination is never completely applied to all components, and this means that a residue remains which must be incinerated. In the best case this will be just the porous parts (wood and paper) unless the solvent technique is applied for long process times, and a product finally obtained which may be sent for land filling if the residual PCB levels are legally acceptable. In other words, the total cost of treatment, including the cost of final disposal of residues, must be taken into consideration.

Table 21: Overview Pre-treatment and Non-Combustion Technologies

Autoclaving
Alkali metal reduction (e.g. dechlorination/dehalogenation processes)
Ball milling
Base catalysed decomposition
Catalytic hydrodechlorination
Gase-phase chemical reduction
Plasma Arc
Potassium tert-butoxide method
Pyrolysis / waste-to-gas conversion technology
Supercritical water oxidation
Vitrification
Bio-degradation

Table 22: Overview Combustion Technologies

High-temperature incineration
Co-incineration in cement kilns

„POPs Technology Specification and Data Sheets" providing detailed information on various decontamination/disposal methods are currently being prepared by the Basel Convention Secretariat.

Two sets of factsheets will describe technologies recommended for the destruction or irreversible transformation of waste consisting of, containing or contaminated with POPs. These factsheets will mainly focus on the following destruction technologies:

- Autoclaving
- Alkali metal reduction
- Base catalysed decomposition
- Co-incineration in cement kilns
- Supercritical Water Oxidation
- Thermal Desorption
- Waste-to gas conversion
- Hazardous waste incineration
- Plasma arc

The latest factsheets shall be published on the website of the BRS Secretariat before the COP 2015. At the moment the provisional data sheets can be downloaded at: *http://www.ihpa.info/resources/library/.*

For further details on the current status of the factsheets the BRS Secretariat in Geneva can be contacted: *brs@brsmeas.org*.

Incineration, is the most widely available and used technology for PCB destruction and remains a final solution. Because of the cost-factor of incineration and its non-availability in many countries, alternative technologies are widely used. Some of those technologies have the advantage not only of lower cost, but also of being able to treat economically much lower volumes of waste material.

Co-processing technologies, if not prohibited by national legislation, shall be implemented according to Basel Convention Technical Guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns as well as the relevant national legislation and regulations

Although oil decontamination can be achieved with technologies allowing complete destruction of PCBs, the carcass of transformers and capacitors can present problems because of the presence of a small amount of porous, organic materials which are costly to treat to obtain complete decontamination.

The techniques and the procedures for the decontamination should be appropriately validated and documented, such that it is possible to predict the reduction, elimination and/or decomposition of specific undesired compounds and elements down to the concentration limit required, without potential hazards or unreasonable risk.

The decontamination activities should utilise Best Available Techniques (BAT) and Best Environmental Practices (BEP) to ensure that, throughout the residual life of equipment and insulating liquids, the quality of dielectric performances and the good functional state of the equipment is maintained. Such techniques should also ensure:

- The best operational conditions for decontamination to prevent direct and indirect damage. Prior to performing the operations, an appropriate safety plan should be prepared which evaluates risk and the appropriate corrective actions in the event of problems, failures, fires, uncontrolled spills or emissions into the environment;
- The dielectric quality and the physical and functional features of the insulating liquids in accordance with the relevant Standards and guides;
- The achievement of the objectives set by the decontamination operations, to be checked by measurement of the concentration of PCBs at the end of the decontamination and after a period of at least 3 months from the re-commissioning of the equipment, under service conditions.

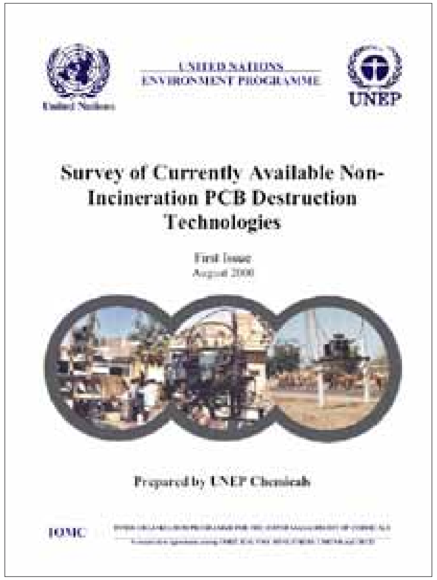
  Transport of PCBs and equipment containing PCBs to companies performing decontamination in locations other than the site of installation of the equipment, should comply with all applicable transport and waste regulations, including the use of identification forms for waste and the waste input/output register. For trans-boundary movements, the Basel Convention applies.

Whatever technology is chosen, it has to be performed by a company which is approved for this task by the competent authorities, and the same if the PCB waste is exported, approved by the competent authority in the country concerned.

In December 2004, the United Nations Environment Programme published an updated version of the inventory of worldwide PCB Destruction Capacity. The UNEP also conducted a survey on currently available non-incineration PCB destruction technologies in 2000. Both documents can be downloaded:

http://www.chem.unep.ch/pops/pcb_activities/pcb_dest/PCB_Dest_Cap_SHORT.pdf; http://www.chem.unep.ch/Publications/pdf/SurvCurrAvNIncPCBDestrTech.pdf

Picture 102: Worldwide PCB destruction capacity 2004



Picture 103: Non-incineration PCB technologies 2000

Further UNEP guidance documents as well as training manuals are available from:

http://www.chem.unep.ch/Pops/pcb_activities/default.htm; http://www.basel.int/meetings/sbc/workdoc/techdocs.html

Picture 104: UNEP training manual for Hazardous Waste Project Managers from October 2002

ANNEXES

12. 1 In-Depth Information on the Internet: Conventions and Guidance Documents

- Basel Convention
  www.basel.int
- Stockholm Convention
  www.pops.int
- PEN PCB Elimination Network
  www.pops.int/pen/
- Guidance documents on PCBs
  http://chm.pops.int/Implementation/PCBs/DocumentsPublications/tabid/665/Default.aspx
- Rotterdam Convention
  www.pic.int
- UNEP Chemicals, many useful reports can be viewed and downloaded via this website
  www.chem.unep.ch
- GPA Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, a lot of useful information
  www.gpa.unep.org
  Identification of PCB containing capacitors, manual for electricians, very detailed list, Australia, 1997
  http://www.scew.gov.au/sites/www.scew.gov.au/files/resources/378b7018-8f2a-8174-3928-2056b44bf9b0/files/anzecc-gl-identification-pcb-containing-capacitors-information-booklet-electricians-and-electrical.pdf
  Guidelines for the Identification of PCBs and Materials Containing PCBs, UNEP 1999
  http://www.pops.int/documents/guidance/nipsfinal/pcbid1.pdf
- GEF - Global Environment Facility
  www.gefweb.org
- UNITAR - United Nations Institute for Training & Research
  www.unitar.org
- UNIDO – United Nations Industrial Development Organization
  www.unido.org
- Recommendations on the Transport of Dangerous Goods – Model Regulations
  http://www.unece.org/trans/danger/publi/unrec/rev16/16files_e.html
- International Chemical Safety Cards
  http://www.cdc.gov/niosh/ipcs/icstart.html#language
- Minamata Convention
  http://www.mercuryconvention.org/
- SAICM – Strategic Approach to International Chemicals Management
  http://www.saicm.org/
- REACH – Registration, Evaluation, Authorisation and Restriction of Chemicals
  http://ec.europa.eu/enterprise/sectors/chemicals/reach/index_en.htm

Please note that many documents and publications are under revision. Therefore please check the actualities in the World Wide Web periodically.

Guidance documents for identification, management and destruction of PCB

- Destruction and decontamination technologies for PCBs and other POPs wastes under the Basel Convention. A training manual for hazardous waste project managers Secretariat of the Basel Convention
  http://archive.basel.int/meetings/sbc/workdoc/TM-A.pdf
  http://archive.basel.int/meetings/sbc/workdoc/TM-B.pdf

- Guidelines for the identification of PCBs and materials containing PCBs
  UNEP Chemicals
  http://www.chem.unep.ch/Publications/pdf/GuidIdPCB.pdf

- Inventory of World-wide PCB Destruction Capacity
  UNEP Chemicals
  http://www.chem.unep.ch/pops/pcb_activities/pcb_dest/PCB_Dest_Cap_SHORT.pdf

- PCB Transformers and Capacitors - From Management to Reclassification and Disposal
  UNEP Chemicals
  http://www.chem.unep.ch/Publications/pdf/PCBtranscap.pdf

- Provisional POPs Technology Specification and Data Sheets
  Secretariat of the Basel Convention
  http://www.ihpa.info/library/2009/08/02/pops-technology-specification-and-data-sheets/

- Selection of Persistent Organic Pollutant Disposal Technology for the Global Environment Facility
  A STAP advisory document
  http://www.thegef.org/gef/pubs/STAP/selection-persistent-organic-pollutant-disposal-technology-gef

- Survey of Currently Available Non-Incineration PCB Destruction Technologies
  UNEP Chemicals
  http://www.chem.unep.ch/Publications/pdf/SurvCurrAvNIncPCBDestrTech.pdf

- Updated general technical guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants (POPs)
  Basel Convention
  http://chm.pops.int/Portals/0/flash/popswastetrainingtool/eng/All_technical_guidelines_on_POPs_4.pdf

- Updated 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)
  Basel Convention
  http://archive.basel.int/pub/techguid/tg-PCBs.pdf

- Draft guidelines on best available techniques and provisional guidance on best environmental practices relevant to Article 5 and Annex C Stockholm Convention
  http://www.pops.int/documents/guidance/batbep/batbepguide_en.pdf

Please note that many documents and publications are under revision. Therefore please check the actualities in the World Wide Web periodically.

12.2 Detection Kits and Other Instruments

Clor-N-Oil (oil samples) and Clor-N-Soil (soil samples)
This kit can test transformer oil for PCB presence. This test uses a colour charge to indicate the presence of chlorine and therefore the likely presence of PCBs. This detection kit can be obtained from the Dexsil Corporation. For more information the manufacturer may be reached at:

Dexsil Corporation
One Hamden Park Drive
Hamden, Connecticut 06517
USA Phone: +1 203 288 3509
Fax: +1 203 248 6523
E-mail: *info@dexsil.com*
Internet: *www.dexsil.com*

L2000 PCB/Chloride Analyser (oil, soil, water and surface wipe samples)
This kit is designed to be used in the field to test for PCBs in soil, transformer oil, water, and on surfaces. The test first react the sample with a reagent that strips all chlorine from the organic molecule. Then a chloride specific electrode determines PCB concentration in the reacted sample. For more information the manufacturer may be reached at:

Dexsil Corporation
One Hamden Park Drive
Hamden, Connecticut 06517
USA Phone: +1 203 288 3509
Fax: +1 203 248 6523
E-mail: *info@dexsil.com*
Internet: *www.dexsil.com*

DR/800 Series Colorimeters (water samples)
This is a small colorimeter that can check for PCBs (chloride) in water. It is designed for field use. For more information the manufacturer may be reached at:

Hach Company
P.O. Box 389
Loveland, Colorado 80539-0389
USA Phone: +1 970 669 3050
Fax: +1 970 669 2932
E-mail: *csays@hach.com*
Internet: *www.hach.com*

DR/4000 UV-VIS Spectrophotometer (water samples)
This kit can perform water quality analysis. This spectrophotometer allows for both manual and sipper testing. It comes pre-programmed with 130 Hach methods of analysis but it can be programmed to perform other water quality analyses as well. For more information the manufacturer may be reached at:

Hach Company
P.O. Box 389
Loveland, Colorado 80539-0389
USA Phone: +1 970 669 3050
Fax: +1 970 669 2932
E-mail: *csays@hach.com*
Internet: *www.hach.com*

12.3 PCB Pre-Treatment Technologies (Extract only)

Transformers are drained in a first step. The liquids will be disposed of separately. The "empty" transformer still contains approx. 3 to 10 % liquid. 10 % is related to Askarel because of the higher density. Additionally, the content of wood, paper etc. is responsible for the remaining liquid. Separate treatment is necessary for transformers. "Pure" PCB transformers cannot be cleaned economically for re-use. The same applies to all other devices that contain "pure" PCB.

Thus transformers need specific treatment. In case of Askarel transformers, solvent extraction is a possibility. Some companies put the core into an autoclave and extract PCB by solvent and vacuum. Empty carcasses are cleaned the same way. Alternatively, the transformer itself can be used as autoclave, and solvent is circulated through the empty transformer. In both cases the solvent is re-distilled, and the PCBs are exported to be incinerated. Various studies have shown that only solvent can remove Askarel from non-porous materials. The use of unchlorinated solvents would be more ecological, their low flashpoint, however, increases the inflammability risk. Therefore, chlorinated solvents like Perchlorethylene are used. Special attention must be paid to the potentially occurring emissions.

After these cleaning processes transformer coils are carefully disassembled. Porous parts still do contain PCB in the interior parts, and are packed into suitable packaging for final disposal at licensed facilities. Even after that pre-treatment by solvent, PCBs are still present the winding and between the core sheets. Therefore, core sheets and winding require additional cleaning processes in specific washing machineries using again solvent. After that procedure random samples must be taken in order to check the success of the process. If all metal parts are PCB-free they can be sold as secondary raw material.

12.4 PCB Non-Combustion Technologies

Dechlorination in general: Chemical dechlorination is based on reactions with either an organically bound alkali metal or an alkali metal oxide or hydroxide. Dechlorination processes are well developed for the treatment of liquid PCBs and PCB contaminated oil. The chlorine content is converted to inorganic salts which can be removed from the organic fraction by filtration. Reactions take place under inert atmosphere. Some companies provide mobile treatment plants, which can be used on an operating transformer in the field. There are several types of this technology available. Two suppliers of dechlorination technologies, and their processes are briefly described below:

Continuous Dehalogenation Process (CDP)
The CDP Process®, developed and patented by Sea Marconi, is a process capable of detoxifying and dehalogenating the PCBs present both in the oil and the inner parts of the transformer on-site, in continuous mode and closed circuit, with circulation of warm oil, with an efficiency of 99.9 %, in accordance with European Directive 59/96. The Decontamination Mobile Units (D5MU) used for the process designed and developed by Sea Marconi implement innovative technologies and unique environmental protection systems, to ensure safe working conditions. The D5MU are modular, thus they can operate in all logistic scenarios and thanks to specially developed ad-hoc protocols, they can also operate on energized and under load transformers.

SDMI Oil Dechlorination Process
The process developed by SD Myers (http://sdmyers.com/pcb-dechlorination.html) is very specific in the scheduled wastes it is able to treat, as it is designed to treat PCB contaminated transformer oils with concentrations below 10'000 mg/kg without the need to remove the transformer or take the transformer out of service. Concentrations below 2 ppm are achievable. It involves circulating the transformer fluid through a filtration system until the residual PCB concentrations are below those required. The continued circulation of the fluid through the transformer largely flushes the PCBs from the transformer windings and other internal components. The treated oil is then suitable for continued use. Leaching from the porous parts of the transformer such as wood and paper insulation can occur and the transformer may require another treatment after some time.

A general overview of non-combustion technologies is given in the next paragraphs:

Alkali metal reduction: Alkali metal reduction involves the treatment of wastes with dispersed alkali metal. Alkali metals react with chlorine in halogenated waste to produce salts and non halogenated waste. Typically, the process operates at atmospheric pressure and temperatures between 60°C and 180°C. Treatment can take place either in situ (e.g. PCB contaminated transformers) or ex situ in a reaction vessel.
There are several variations of this process. Although potassium and potassium-sodium alloy have been used, metallic sodium is the most commonly used reducing agent. [*Technical Guideline, Basel Convention*].
Sodium- and ammonium reduction technologies are capable for any kind of contamination of PCB, but not economical at higher level. The maximum economical level of PCB varies between 2'000 to 5'000 mg/kg PCB. The technologies have been widely used in Canada, USA and Europe for treatment of PCB-contaminated transformer oil. One of the advantages is that the oil after further treatment can be reused. There are several providers of the technology around the globe. The ammonium technology is comparable to sodium technology but rather seldom and not easy to handle.

Ball milling: This is an interesting new technology where a ball mill is used with excess CaO resulting in decomposition of chlorinated compounds. Reports show high destruction efficiencies for individual chemicals. However, the method is still in development stage and there is a lack of independent emission statistics. The operating costs may be high due to the amount of CaO and electricity needed in the process.

Base catalysed decomposition (BCD):
The BCD process involves treatment of wastes in the presence of a reagent mixture consisting of hydrogen-donor oil, alkali metal hydroxide and a proprietary catalyst. When the mixture is heated to above 300°C, the reagent produces highly reactive atomic hydrogen. The atomic hydrogen reacts with the waste to remove constituents that confer the toxicity to compounds. *[Technical Guideline, Basel Convention]*.
The BCD process is limited to a certain PCB content, which however is above 10'000 ppm. BCD has been used at two commercial operations within Australia, with one still operating. Most recent experiences have been gained at one of the largest Dioxin sites in the world, the Spolana Site in Czech Republic, where tens of thousands of tons of contaminated soils and several thousands of tons of 50 % chlorine pesticides, etc. have been treated. Thanks to these experiences in Spolana, BCD units have been improved in such a way that up to 1000 t/y of high chlorine content PCBs or pesticides (50%) can now be treated in a single line.

Catalytic hydrodechlorination (CHD):
CHD involves the treatment of wastes with hydrogen gas and palladium on carbon (Pd/C) catalyst dispersed in paraffin oil. Hydrogen reacts with chlorine in halogenated waste to produce hydrogen chloride (HCl) and non-halogenated waste. In the case of PCBs, biphenyl is the main product. The process operates at atmospheric pressure and temperatures between 180°C and 260°C. *[Technical Guideline, Basel Convention]*
In Japan the CHD technology is implemented by JESCO (Japan Environmental Safety Corporation) which is a special company wholly owned by the government, established in 2004. JESCO's mission is to construct and operate five regional facilities to treat PCBs wastes in Japan, and one of them is the CHD Osaka PCB Waste Treatment Facility. The Japanese plant can treat up to 100% PCBs and is also combined with units to clean PCB transformers: Solvent Cleansing Method and the Vacuum Heating Separation Method. An interesting option is the CHD technology implemented by Hydrodec, which has treatment facilities in Young, NSW, Australia, and Canton, Ohio, USA. They transform used oil into a high quality naphthenic based transformer oil or base oil called SUPERFINE™. The plant in Ohio, can treat low level PCB-contaminated transformer oil up to 49 ppm, (EPA permit for up to 2,000 ppm pending approval) *(http://www.hydrodec.com/product-and-services/north-america/used-oil-collection-and-treatment).*
In 2011, the company started a joint-venture with Kobelco Eco-Solutions. It is planned to set up the first plant in Japan during the second half of 2012.

Gas-phase chemical reduction (GPCR): The GPCR process involves the thermochemical reduction of organic compounds. At temperatures greater than 850°C and at low pressures, hydrogen reacts with chlorinated organic compounds to yield primarily methane and hydrogen chloride. *[Technical Guideline, Basel Convention]*. All PCBs from Western Australia were treated by GPCR in the 2000s. No commercial facility is in operation today, the methodology is rather expensive.

Plasma Arc: The Plascon™ process uses a plasma arc with temperatures in excess of 3,000° C to pyrolyse wastes. Together with argon, wastes are injected directly into the plasma arc. The high temperature causes compounds to dissociate into their elemental ions and atoms. Recombination occurs in a cooler area of the reaction chamber, followed by a quench, resulting in the formation of simple molecules. *[Technical Guideline, Basel Convention]*.
This technology can destroy up to the

highest level of PCB with an efficiency of 99.99999 %. The plasma arc technology is used regionally on a commercial basis but is rather low in capacity. Due to the extreme high temperature the disposal costs are very high. Installations are small with standard units (each unit 150kW) and can be used as mobile or as fixed plants. A PLASCON® plant can destroy pure PCBs at a rate of 35 to 40 kg/h *(http://www.plascon.com.au/destruction-of-pcbs.html).* In January 2011 there were 10 commercial plants operating with licenses from the Victorian and Queensland EPAs in Australia, the UK EPA, the US EPA, the Mexican EPA, and the Japanese Ministry of the Environment. 4 commercial 150 kW "in-flight" plasma arc units are operating in Australia. 2 units were installed at Nufarm Ltd (Pesticides producer).

Potassium tert-butoxide method: PCBs in insulating oils are dechlorinated by reaction with potassium tert butoxide (t-BuOK). It reacts with chlorine in PCBs to produce salt and non chlorinated waste. Typically, the process operates at atmospheric pressure and temperatures between 200°- 240°C. *[Technical Guideline, Basel Convention]*. (up to now only implemented in Japan).

Pyrolysis / waste-to-gas conversion technology: The process is a gasification pre-treatment and treatment technology for the recovery of hydrocarbon-containing waste operating at high temperatures (1300°C–2000°C) and high pressure (about 25 bar) using steam and pure oxygen in a reducing atmosphere. All hydrocarbon molecules in the waste are irreversibly cleft into small gaseous molecules such as hydrogen (H_2) and carbon monoxide (CO), methane (CH_4) and carbon dioxide (CO_2). Short-chain hydrocarbons such as ethane (C_2H_6), propane (C_3H_8) and butane (C_4H_{10}) and other compounds are produced in small amounts (< 1 vol. %). PCBs contained in the waste are effectively destroyed. The resulting raw gas is subsequently converted in a multistage process to pure synthesis gas for the production of highest-grade methanol. *[Technical Guideline, Basel Convention]* There was only one plant in the world using this technology, Schwarze Pumpe, Germany, which, however, was already closed some years ago.

Supercritical water oxidation: SCWO and subcritical water oxidation treat wastes in an enclosed system using an oxidant (such as oxygen, hydrogen peroxide, nitrite, nitrate, etc.) in water at temperatures and pressures above the critical point of water (374°C and 218 atmospheres) and below subcritical conditions (370°C and 262 atmospheres). Under these conditions, organic materials become highly soluble in water and are oxidized to produce carbon dioxide, water and inorganic acids or salts. [Technical Guideline, Basel Convention]. At present the largest SCWO plant (10 000 t/y) in the world is under construction in the US for the destruction of Chemical Warfare agents (ACWA programme).

Vitrification (Geomelt): This technology has been widely applied for remediation of PCBs in soil. The process works by establishing a melt between pairs of electrodes inserted into the soil-bound waste materials. This treatment of PCB containing equipment and oil can only be recommended under certain specific conditions.

Bio-degradation: The bio-degradation is very limited in the contamination level and can be excluded for treatment of PCB-containing equipment and oil. From experience we know, however, that Bio-degradation can be considered for treatment of low-contaminated soils.

12.5 PCB Combustion Technologies

High-temperature incineration is the most common technology for destruction of waste with high PCB content in Europe and North America. Modern incinerators have an efficiency of at least 99.99999 % for highest levels of PCB. In order to reach this destruction efficiency the incinerators operates at temperatures higher than 1,100 °C, with a residence time greater than 2 seconds, under conditions that assure appropriate mixing The disposal costs are in general lower for waste with high content PCB than for the other disposal methods.

In some countries public resistance against hazardous waste incineration has led to the development of different non-incineration technologies although the disposal costs may be higher for these technologies. The formation of dioxins and furans by the incineration has been one of the main concerns. If high temperature incineration is used the incinerator should meet a limit value for emission of dioxins and furans of <0.1 ng I-TEQ/Nm3 at 11% O2. Most incinerators are large stationary facilities but in some countries e.g. Canada also small mobile incinerators are operating on a commercial basis. Their capacities are low compared to the stationary ones.

High temperature incineration is the main solution in Europe for "pure" PCB. Various incinerators guarantee extreme low emissions. The incinerators can accept all types of PCB waste that can either be pumped (liquids) or packed into drums. PCBs in drums are fed into the incinerator kiln by elevator. Liquids are usually pumped from storage tank through injectors into the kiln. Transformers have to be dismantled prior to disposal, due to their size.

Co-incineration in cement kilns: The co-incineration of PCB containing liquids is usually limited to the range of 50 to 1,000 ppm PCB in the oil. Higher levels of chlorine would have negative impact to the quality of cement. As rule of thumb, chlorine should usually be limited to 300 to 500 g/t cement clinker for a kiln without by-pass and 400 to 750 g/t for a kiln with by-pass, but the chlorine tolerance most be known in each instance. It is important that the process owner knows the chlorine tolerance of the process in question. Additionally, the co-incineration requires proper flue gas cleaning systems.

A number of tests of PCB destruction have demonstrated that the PCB can be satisfactory destructed in the kilns, but large scale use of cement kilns for destruction of PCBs has not been reported from developing countries. If cement kilns are used to incinerate wastes, the standards of the applicable regulations have to be met. One can refer to the regulation 94/67/EG of the European Council on the incineration of toxic wastes.

12.6 PCB Emerging Technologies

There are a number of emerging technologies, which are not presented in the frame of this handbook. There is a GEF supported "review of emerging, innovative technologies for the destruction and decontamination of POPs and the identification of promising technologies for the use in developing countries" available in the internet:
http://www.chem.unep.ch/pops/pcb_activities/PCB_proceeding/Presentations/PCB%20Global%20McDowall.pdf

and
http://www.chem.unep.ch/Pops/pcb_activities/default.htm#Guidance

12.7 PCB Treatment and PCB Disposal Companies

Enterprises from all around the world are listed under the following link:

http://www.chem.unep.ch/pops/pcb_activities/questionnaire/default.htm

Please note that some websites might be archived in March 2015. Please check periodically the WWW about new publications and downloads.

12.8 Emergency Response Plan for Cold Incidents

The following table shows the measures to be taken in case of PCB incidents. For each nature of spill the order of the actions to be taken is indicated by the numbers.

Emergency Response for Cold PCB Incidents

	Nature of spill			
	Leakage into containment system	**Spill on concrete and asphalt**	**Spill on soil**	**Spill into water**
Notify plant personnel, chemical response and competent authorities	1	1	1	1
Inform responsible doctor and put on adequate Personal Protective Equipment (avoid personal contamination!)	2	2	2	2
Prevent people and/or vehicles from entering the contaminated areas	3	3	3	3
If applicable: Disconnect the concerned equipment from power Check earthing	4	4		
Plug or dike all drains to sewers and ditches, use absorbents (sand, cement)		5	4	
Stop source: Seal leak by using appropriate materials, place drip-tray under leak	5	6	5	4
Spill confinement: Build dikes to contain PCB in small area		7	6	
Cover with plastic to minimize runoff from rain		8	7	
Dam area if possible, and close off to vessels in navigable water				5
Confine contaminated area, Erect tent with compartments	6	9	8	
Use pump to transfer PCBs into drums, Soak up PCB with absorbents	7	10	9	6
Use dredges to collect the contaminated soil / sediment			10	7
Repeated solvent scrub process followed by a sorbent clean-up	8	11		
Take core sample to determine remaining contamination		12 (2,5 cm depth)	11 (60 cm depth)	
Break off contaminated concrete		13		
Pack wastes according to ADR and dispose as hazardous waste	9	14	12	8
Monitor wells and other bodies of water in the vicinity for PCB contamination			13	

12.9 Emergency Response Plan for Hot Incidents

The following table shows the measures to be taken in case of PCB incidents. For each nature of spill the order of the actions to be taken is indicated by the numbers.

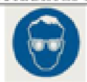
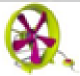
Emergency Response for Hot PCB Incidents

	Nature of Incident		
	Internal failure **No bursting of equipment**	**Internal failure of capacitor** **Bursting of equipment with spill** **Beware of highly toxic furans!**	**Fire in vicinity of equipment** **Beware of highly toxic furans and dioxins!**
Notify fire brigades			**1**
Notify plant personnel, chemical response and competent authorities		**1**	**2**
Inform responsible doctor and put on adequate Personal Protective Equipment (respiration mask!)		**2**	**3**
Prevent people from entering the contaminated areas		**3**	**4**
Disconnect the concerned equipment from power	**1**	**4**	**5**
Phase out equipment	**2**		
Evacuate and close the building, cut out air circulation by plugging vents		**5**	**6**
Stop source: Seal leak with appropriate materials, place drip-tray under leak		**6**	
Confine contaminated area		**7**	**7**
If not protected by a heavy protective overall keep clear from danger zone, Let the specialists extinguish the fire			**8**
Erect tent with compartments		**8**	**9**
Repeated solvent scrub process followed by a sorbent clean-up		**9**	**10**
Take core sample to determine penetration		**10 (2,5 cm deep)**	**11 (60 cm deep)**
Take wipe samples for dioxin			**12**
Break off contaminated concrete		**11**	**13**
Use dredges to collect the contaminated soil / sediment		**12**	**14**
Pack wastes according to ADR and dispose as hazardous waste	**3**	**13**	**15**

12.10 Best Working Practices

Best Working Practices

When performing light repair or maintenance work with PCB-containing equipment, the following safety precautions for the protection of the employees and the environment have to be followed:

 	Direct contact of PCB-contaminated materials with the skin and eyes has to be absolutely avoided by wearing gloves and safety goggles. According to the type of the work performed, protection clothing and a respiratory mask has also to be put to the workers disposal.
	The working area has to be adequately ventilated.
	Spills have to be prevented in every case by use of drip trays or adequate plastic tarps.
	Every contact of PCBs with a flame or any other heat source over 300°C has to be absolutely avoided (risk of highly toxic dioxines and furanes).
	All used tools and other working materials, which got in contact with PCBs, have to be disposed of as PCB-containing waste in a environmentally sound manner or otherwise have to be decontaminated. The only suitable materials to be decontaminated with an appropriate solvent (technical acetone) are steel, glass and ceramics.
	Operations which involve decanting, rewinding of coil, etc. must only be performed by companies approved for this task by the competent authorities.

12.11 PCB Instructions for Workers

The below instruction card shall be regarded as an adequate example of PCB instructions for workers and emergency cases. However, the information and pictograms may change.

Instruction No. 03/2010 | Company:
Acc. §14 Ordinance on Hazardous Substances
Building site/Work: Printdate:

Polychlorierte Biphenyle
PCB are suspected of causing cancer!

Hazards for human health and the environment

Breathing in, swallowing or absorption through the skin may result in health damage. May cause irritation (respiratory tract, eyes, skin, organs of digestion). Temporary complaints (dizziness, fatigue, nausea, loss of appetite) are possible. Can cause acne, digestive disorders, liver damage, blood picture changes, mood disorders. Carcinogenic effect is suspected. PCB can affect reproductive fertility. PCB can be injurious to the unborn child. Reichert sich im Körper an! Beim Erhitzen oder Verbrennen können sehr giftige Dioxine und Furane entstehen.
Hazardous to water - avoid ingress into the ground, water and sewage!

Protective measures and behaviour rules


Ensure a fresh air supply when working! In the event of vapours, work only with exhaust ventilation! Nicht mit Feuer, offenen Flammen oder heißen Metallteilen in Berührung bringen! Do not leave vessels open! Avoid splashes! Do not mix with other products or chemicals! Avoid contact with eyes, skin and clothing! Preventive skin protection necessary. Thoroughly clean hands and face after completing work and before every work break! Use skin care agent! Store street clothing separately from work clothing! Change clothing after completing work! Change soiled clothing!
Observe restrictions on activity!
Eye protection: Full protection goggles!
Hand protection: Gloves made of: fluororubber.
It is advisable to wear cotton gloves underneath protective gloves.
Breathing protection: The use of A2-P3 (braun-weiß) is recommended.
In pits, shafts and silos, only use ambient air-independent breathing apparatus!
Skin protection: Use grease-free skin protection ointment for all uncovered parts of the body:
Body protection: (Disposable) chemical protective suit and plastic boots. Bei Bedarf partikeldichte Schutzkleidung!

Behaviour in danger situations

Collect and dispose of with absorbent non-combustible material (e.g. kieselguhr, sand)! Evacuate the workplace if large quantities should leak! Remove only after applying persönlicher Schutzausrüstung! Product is not combustible. In the event of a fire in the environment, cool the receptacle with sprayed water! Hazardous vapours are produced in the event of fire! Only fight larger fires using self-contained breathing equipment and suitable protective equipment!
Responsible physician or clinic:
Accident phone:

First Aid

During all First Aid assistance: protect yourself and immediately inform a doctor.
After eye contact: Rinse for 10 minutes with water or with eye-wash solution.
After skin contact: Take off soiled clothing immediately. Clean with abundant amounts of water and soap. No thinners!
After breathing in: Fresh air. Keep airways clear: remove false teeth, vomit etc.. If breathing or heartbeat stops: immediately apply artificial respiration and heart massage.
After swallowing: Do not cause vomiting. If conscious, see that plenty of water is drunk a little at a time. No domestic agents.
First Aid specialist:

Proper disposal

Do not pour into the sewage or a refuse bin!
Product residues:
For disposal, collect in:

12.12 First Aid in Case of Contact with PCBs

Table 23: First Aid Measures

Kind of Exposure	Measure
➢ Liquid PCB on the skin	➢ Use water and soap to wash thoroughly
➢ Liquid PCB in the eyes	➢ Rinse eyes with lukewarm jets of water for 15 minutes, always keeping eyes wide open
➢ Liquid PCB in the mouth and in the stomach	➢ Rinse mouth with water, do not drink anything else, see doctor immediately
➢ Highly concentrated vapors of PCB	➢ Take affected people outside in the open air

12.13 Guidelines for the Inspection of Sites and the Sampling of Transformers and Capacitors (two persons)

The Field Teams for the identification of PCB equipment comprise of three members. The inspector as official authority will monitor the process of sampling and ensure the quality of the inventory process.

Field Team Member 1		Field Team Member 2
Unlock the door/gate to the room with capacitors	1	
Locate capacitors, read the producer's plate	2	Fill in the inventory form for the capacitor and in the upper right space copy the number from the label
Read each line of the producer's plate	3	Fill in the necessary data from the producer's plate, line by line
Measure the capacitors' dimensions	4	Write down the dimensions of the capacitors
Prepare the label for capacitors and affix it on a clean and accessible place on the capacitor (example: 10404)	5	
Take picture of the capacitor	7	
Check if there is any leakage or damage on the capacitor	8	Note down in the inventory form where the leakage or damage has been detected on the capacitor
Lock the room with capacitors	9	
Unlock the door/gate to the room with transformers	10	
Locate transformers, read the producer's plate	11	Fill in the inventory form for the transformer and in the upper right space copy the number from the label
Read each line of the producer's plate	12	Fill in the necessary data from the producer's plate, line by line
Take sample of transformer oil	13	
Affix sampling label on transformer, sampling vial, and write it on the inventory form	14	Check if there is any leakage or damage on the transformer
	15	Take picture of the transformer (if there are any leakages, damages, corrosion)
Dispose the sampling materials (pipettes, adsorbent pads, gloves) in plastic bags that will later be stored in barrels and containers for that purpose.	16	Note down in the inventory form where the leakage or damage has been detected on the transformer
Lock the room with transformers	17	

12.14 Draft Inventory Questionnaires

There are a number of inventory questionnaire proposals, amongst them also the initial UNEP proposal from 2002, see e.g. on this site:

http://www.google.ch/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CB4QFjAA&url=http%3A%2F%2Fwww.pops.int%2Fdocuments%2Fguidance%2FPCBinvform.doc&ei=bnb1VMaJFYvnUr6xgtAK&usg=AFQjCNE8mfNujwIGZxuycEuZbNIe2lg99g&sig2=yuimZwcO4WVxE39Y7ZLejQ

It is recommended that countries design their own country-tailored questionnaires, based on the UNEP recommendation respectively the BRSMEAS Guidelines and respective experiences.

Below and until page 99, there are some draft forms based on the initial UNEP Questionnaire which have been used in many countries as a basis for the PCB Assessment.

Often these forms have been used at the same time as sampling reports.

Form A: Information about the company, site and equipment which contains / is contaminated with PCB

№	Information about the company, site and equipment which contains / is contaminated with PCB		
1	Name:		
2	Address:		
3	Address of site:		
4	Phone :		
	Fax:		
	E-mail:		
5	Name/Position of contact person:		
6	Type of company / industry type/ production at specific site:		
7	Public or private company?		
8	Location:	Industrial zone	
		Urban area	
		Rural area	
9	Number of personnel:	>50	
		10-50	
		<10	
10	Total number of pieces of equipment at site:	Transformers	
		Capacitors	
		Others	

Form B: Information related to the potentially PCB containing equipment

Oil-filled Equipment Inventory Form			
1	Name of the equipment		
2	Individual Identification Number (IIN) of the equipment		
3	Type and trademark of the equipment		
4	Serial number		
5	Manufacturer and country of origin		
6	Location of equipment		
7	Maximum permissible power capacity		
8	Year of production		
9	Physical parameters:	Total weight (kg)	
		Volume/weight of oil (liters or kg)	
		Equipment (dry weight, kg)	
		Dimensions of equipment (length, width, height, m)	
10	Oil trademark		
11	Does the oil contain PCB?		
12	How did you identify the oil as PCB-containing or PCB-free?		
13	Operational status	In service	
		Stand-by	
		Decommissioned	
14	Condition of the equipment	Any leakages detected?	
		Is the floor under equipment (concrete, soil) contaminated?	
		Any external evidence of the equipment damage (corrosion, cracks etc.)?	
		Storage situation (e.g. open air, in a workshop etc.).	

15	Service, maintenance and care; current repair of the equipment.	What company provides equipment maintenance services?	
		Type of oil used for retrofilling?	
		Fluid replaced? If yes, when was the last replacement done?	
		What company replaced the fluid?	
		What was the trademark of replacement insulation fluid or oil? (Name in original language)	
Name, position of person in charge and executor, signature, date			
16	Person in charge:	Signature	Date
17	Executor:	Signature	Date

Form C: Information on wastes liable to contain PCB

C Information on wastes liable to contain PCB				
1	Nature of the wastes (*e.g.*, transformer oil in drums or reservoirs)			
2	Estimated quantity			
3	Are containers leak-proof?			
4	Is the place of storage clearly marked to show the presence of PCB?			
5	Have soil or buildings been contaminated by leaking PCB? (indicate magnitude of problem if possible, *e.g.* tonnes or cubic metres of contaminated soil)			
6	Brief history of any previous remediation efforts, *e.g.*, removal of PCB-containing equipment and waste PCB for disposal (when, by whom, where to, *etc.*)			
7	Other relevant information (*e.g.*, results of any sampling and analysis already undertaken)			
8	Fill in:	Name and surname	Signature	Date

12.14.1 Preliminary Inventory Form used in the Regional Pilot Project

Preliminary Inventory form of PCBs

General Data				
1	**Inventory record No.**			
2	Date			
3	Inspector name			
4	Name of establishment			
5	Address, phone, mail, fax			
6	Name of managing head			
7	Position GPS			
8	Land use classification	• Urban		
		• Industrial		
		• Rural		
9	**Industry Classification**			
	Code			
	Description	• Manufacturing		
		• Service		
		• Transport		
		• Commercial		
		• Utilities		
		• Other*(please specify)*		
10	Potential Receptors	• School		km
	Indicate distance (in kilometers) for each applicable receptor.	• Hospital		km
		• Commercial Buildings		km
		• Storage of Flammable Material		km
		• Other *(please specify)*		km
Analysis				
11	Sampling No.			
12	Date of sampling			
13	Density test*	Positive		
		Negative		
		No test		
14	Chlorine test	< 50 ppm		
		> 50 ppm		
		No test		
15	Chlorine concentration ppm			
16	PCB concentration ppm			
17	Name of laboratory			
18	Laboratory recognition/ accreditation number			

*only in case of emergency
**: if applicable

Technical Data			
19	Serial number		
20	Type of equipment/ appliance/ packing	• Transformer	
		• Capacitor	
		• Circuit breaker	
		• Drum containing liquid	
		• Drum containing solid	
		• Contaminated soil associated to the equipment	
		• Others, please specify	
21	Operational Status of equipment	• In use	
		• Out of use	
		• Stand by	
		• In storage area	
		• Ready for decommissioning	
22	Manufacturer name list no**		
23	Dielectric name list no**		
24	Power [KVA] (KVAR) **		
25	Year of manufacture **		
26	Year of installation on site **		
27	Total weight **		
28	Weight of dielectric oil **		
29	Filling level **	• Full	
		• Half	
		• Empty	
30	Leaking of appliance	• Top	
		• Middle	
		• Bottom	
		• No leaking	
31	Corrosion on the appliance	• Top	
		• Middle	
		• Bottom	
		• No corrosion	
32	Retrofilling**	Yes, indicate when	
		No	
33	Any nearby flammable material?	If Yes give the chemical or technical name	Estimate distance from PCB appliance
		No	km
			km

12.15. Example of a Possible Register

Ord. No	Type of equipment	Trade-mark	IIN	Manufacturer	Year of production	PCB tested
1	Transformer	TM	TC-301	Kentau Transformer Plant	1995	PCB-Free (L2000 Screening)
2	Transformer	TH	TH - 121	Chirchick Transformer plant	1967	PCB-contaminated 486 mg/kg by L2000 & GC Verification
3	Transformer	TON 394/22	THП - 222	Poland	1976	PCB-containing pure PCB (nametag)
4	Capacitor	KCK2-1,05-125-2У	KC - 089	Ust-Kamenogorsk capacitor plant	1985	no testing yet

Total Weight kg	Oil Weight kg	Location	Operation status	Condition	Maintenance and servicing data	Maintenance organization (contact info)
2500	800	Workshop No 1	In service	Satisfactory	Regular topping up	Iskra Ltd., Kokshetau, Abay str. 2
4530	1800	Transformer substation ТПС-010	Phased out	There are oil leaks	Maintenance by Iskra Ltd/	Iskra Ltd., Kokshetau, Abay str. 2
2800	1200	Transformer substation	In service	Satisfactory	Regular topping up and gasket replacement in 2004 .	Iskra Ltd., Kokshetau, Abay str. 2
58	15	Capacitor substation	In backup	Burnt	No maintenance	Iskra Ltd., Kokshetau, Abay str. 2

12.16 PCB Equipment Monthly Maintenance Plan

Place: ____________________________

Date: ____________________________

No.	Item for inspection	Compliant Yes	Compliant No	Observation	Corrective action
PCB Transformers					
1.	Inventory number				
2.	Condition of gauges				
3.	Reading of gauges				
4.	Corrosion on tanks and radiator fins				
5.	Paint finish of tank and radiator fins				
6.	PCB leakage from: • tank • radiator fins • top cover • manhole cover • top or bottom drain spout • high and low voltage bushings				
7.	Pressure relief valve				
8.	Drain valve				
9.	High and low voltage bushings				
10.	Color of PCB oil				
11.	Electrical and chemical tests to indicate the physical and electrical properties (dielectric test, power factor test, acidity test, interfacial test) (to be tested yearly)				
12.	Driers (silica gel) state				
13.	Abnormal vibration and noise				
PCB Capacitors					
14.	Inventory number				
15.	Corrosion on casing				
16.	Physical damage				
17.	Leakage of PCB oil				
18.	Melted fuses				
19.	Temperature of capacitor casing				
20.	Bulging				
21.	Bursting				
22.	Repairing and servicing operations, if any				
23.	Was PCB equipment repaired on or off-site (if off-site, state the servicing and transport company)				

Completed By: ____________________________

Contact Phone: ____________________________

12.17 PCB Interim Storage Facility Monthly Inspection Report

Overview: The competent authority is required to inspect the institutions' PCB storage site on a monthly basis. This inspection is completed by a qualified individual, recorded below, and forwarded to the environmental authorities.

No.	Question	Yes	No
1	Signage is posted on the exterior of the PCB storage areas and storage areas are secure and only accessible to authorized personnel.		
2	PCB equipment and drums of PCB material are stored in a manner that makes them accessible for inspection and that protects them from catching fire or being released.		
3	PCB storage site is in good condition, including:		
	• Floors		
	• Curbing		
	• Sides		
	• Drains (if present)		
	• Weatherproof roofs		
	• Fences and walls		
4	Indoor PCB storage sites are equipped with, where practical, an appropriate fire suppression system and alarm system to adequately address the quantities of PCBs stored on site.		
5	Has the fire extinguisher been inspected within the last month? Is it in working condition?		
6	Where PCB equipment that is not in a container (other than drained PCB equipment) and contains PCB liquids, is stored on a floor of steel, concrete or any other similar durable material that is capable of absorbing any PCB liquid. The concrete floor and sides are sealed with an impervious, durable, PCB-resistant coating.		
7	PCB equipment not stored in containers and contains PCB liquids is stored on a floor of steel, concrete or any other similar durable material, is dyked to contain: a) for one piece of equipment or container, 125% of the volume of the PCB liquid present; **or** b) for more than one piece of equipment or container, the greater of twice the volume of the PCB liquid in the largest piece or 25 per cent of the volume of all the PCB liquid stored.		
8	PCB storage site floor drains, sumps or other openings in the floor are: a) closed and sealed to prevent the release of liquids, **or** b) connected to a closed drainage system suitable for PCB collection that terminates at a location where any spilled liquids are contained and recovered and where the spilled liquids, **and** c) will not create a fire hazard or a risk to public health or safety.		
9	Stacked containers of PCB material, other than drums, are used only if the containers are designed for stacking, and are stacked not more than two containers high.		
10	Where drums containing PCB material are stacked, separate the drums from each other by pallets and, in the case of drums of PCB liquid, stack the drums not more than two drums high.		

Completed By: ______________________________**Contact Phone:** ________________________________

Please retain a copy for your records and forward the original to: ………………….

12.18 Transboundary Movement and Notification Documents for Hazardous Waste

For the transboundary movement of Hazardous Waste the Proceedings according to the Basel Convention have to be followed and the appropriate forms prepared (see also chapter 1.2).

The Conference of the Parties to the Basel Convention at its eighth meeting (December 2006) adopted revised versions of the forms for the notification and movement documents, including the instructions for completing these forms. These forms can be accessed from the links below: *http://www.basel.int/Portals/4/Basel%20 Convention/docs/techmatters/forms-notif-mov/vCOP8.pdf*

There are other forms available such as e.g. *http://www.pccdaman.info/pdf/Hw%20 Forms/HW%20Form%20-%208.pdf*

Many forms are under revision at the time and will be published soon on the appropriate websites. Please check the actualities in the WWW periodically.

12.19 Dangerous Good Declaration and Container Packing Certificate

DANGEROUS GOODS DECLARATION AND CONTAINER PACKING CERTIFICATE

This form meets the requirements of SOLAS 74, Chapter VII, Regulation 4; Marpol 73/78 Annex III, Regulation 4 and Chapter 5.4 (Documentation), Vol. 1 of IMDG Code.

1 Shipper (Name and Address)	2 Page 1 of __ pages
	3 B/L Number:
4 Consignee (Name and Address)	5 Shipper's Reference Number:
	6 Carrier:

SHIPPER'S DECLARATION:
I hereby declare that the contents of this consignment are fully and accurately described below by the proper shipping name, and are classified, packaged, marked and labelled/placarded and are in all respects in proper condition for transport according to the applicable international and national government regulations.

7 Port of Loading	8 Vessel/Voyage	9 1st Relay Port	10 1st Relay Vessel/Voyage
11 2nd Relay Port	13 2nd Relay Vessel/Voyage	14 Port of Discharge	15 Port of Destination

16 Dangerous Goods Details

Proper Shipping Name	IMO Class	Sub Risk	UN No.	PG	FP	MP Y/N	Gross Wt. (kg)	Net Wt. (kg)	Cube (m^3)	Package No. & Type	
										Inner	Outer

17 Container No.	18 Container Size & Type	19 Seal No.
20 Container Tare Wt. (kg)	21 Total Wt. (kg) (Including Container Wt.)	22 24 hrs Emergency Contact Tel No.

23 Additional Handling Information	**CONTAINER PACKING CERTIFICATE:** **I hereby declare that the goods described above have been packed/loaded into the container identified above in accordance with provision 5.4.2.1 of IMDG Code.**
	24 Name of Company
*** DANGEROUS GOODS: You must specify: proper shipping name, hazard class, UN Number, Packaging Group, Marine Pollutant (where assigned) and observe the mandatory requirements under applicable national and international governmental regulations. For the purposes of the IMDG Code see Provision 5.4.1.4 and DOT-E - CFR 172.203(a)**	25 Name/State of Declarant
	26 Place and Date
	27 Signature of Declarant

12.20. Application Form for Membership in the PEN

UNEP

APPLICATION FORM FOR MEMBERSHIP TO THE PCB ELIMINATION NETWORK (PEN)

PCB Elimination Network (PEN)

1. Personal information

I wish to register as an: ☐ Institution ☐ Individual person

Institution			
First name		Title (*Mr., Ms., Mrs., Dr.*)	
Family name			
Job title			
Mailing address		Postal code	
City		Country	
Telephone	*(please include international code)*	Mobile	*(please include international code)*
Fax		E-mail	

2. Additional information

Please specify to which category of stakeholders you belong (please choose only one category):

☐ Government (ministries, agencies, environmental inspectorates, etc.)
☐ PCB disposal service industry (entities offering maintenance, treatment or destruction of PCB)
☐ PCB owner or holder (private or state enterprises holding contaminated equipment or oils)
☐ Regional centre for the Stockholm or Basel Convention for capacity building and the transfer of technology
☐ Inter-governmental organization
☐ Non-governmental organization
☐ Research institution or academia
☐ Other: ______________________

In the field below, please briefly describe your involvement with PCB.

I am interested in the following topics of the thematic group (multiple checks possible):

☐ Inventory of PCB
☐ Maintenance, Handling, and Interim Storage of Equipment Containing PCB
☐ Disposal of PCB and Remediation of Contaminated Sites
☐ Open Applications of PCB
☐ Other: ______________________

3. Declaration

I hereby declare that I will make determined effort towards achieving environmentally sound management of PCB. I accept that all information provided can be shared publicly.

Date: ______________ **Signature:** ______________________

Please e-mail or mail the completed form to:
Secretariat of the PEN, Chemicals Branch, DTIE, UNEP
11-13 Chemin des Anémones, CH-1219 Châtelaine (GE), Switzerland
E-mail: pen@pops.int or heidelore.fiedler@unep.org

United Nations Environment Programme
Coordinating Unit for the Mediterranean Action Plan
Barcelona Convention Secretariat

Vassileos Konstantinou 48, Athens 11635, Greece
Tel.: +30 210 7273100 – Fax: +30 210 7253196
www.unepmap.org

ISBN: 978-92-807-3521-5

UNEP

MAP

40 Years TOGETHER FOR A SUSTAINABLE MEDITERRANEAN

United Nations Environment Programme
Coordinating Unit for the Mediterranean Action Plan
Barcelona Convention Secretariat

Vassileos Konstantinou 48, Athens 11635, Greece
Tel.: +30 210 7273100 – Fax: +30 210 7253196
www.unepmap.org