Environmental Sound Management (ESM) of PCBs

Global and regional experiences and best practices

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UNITAR

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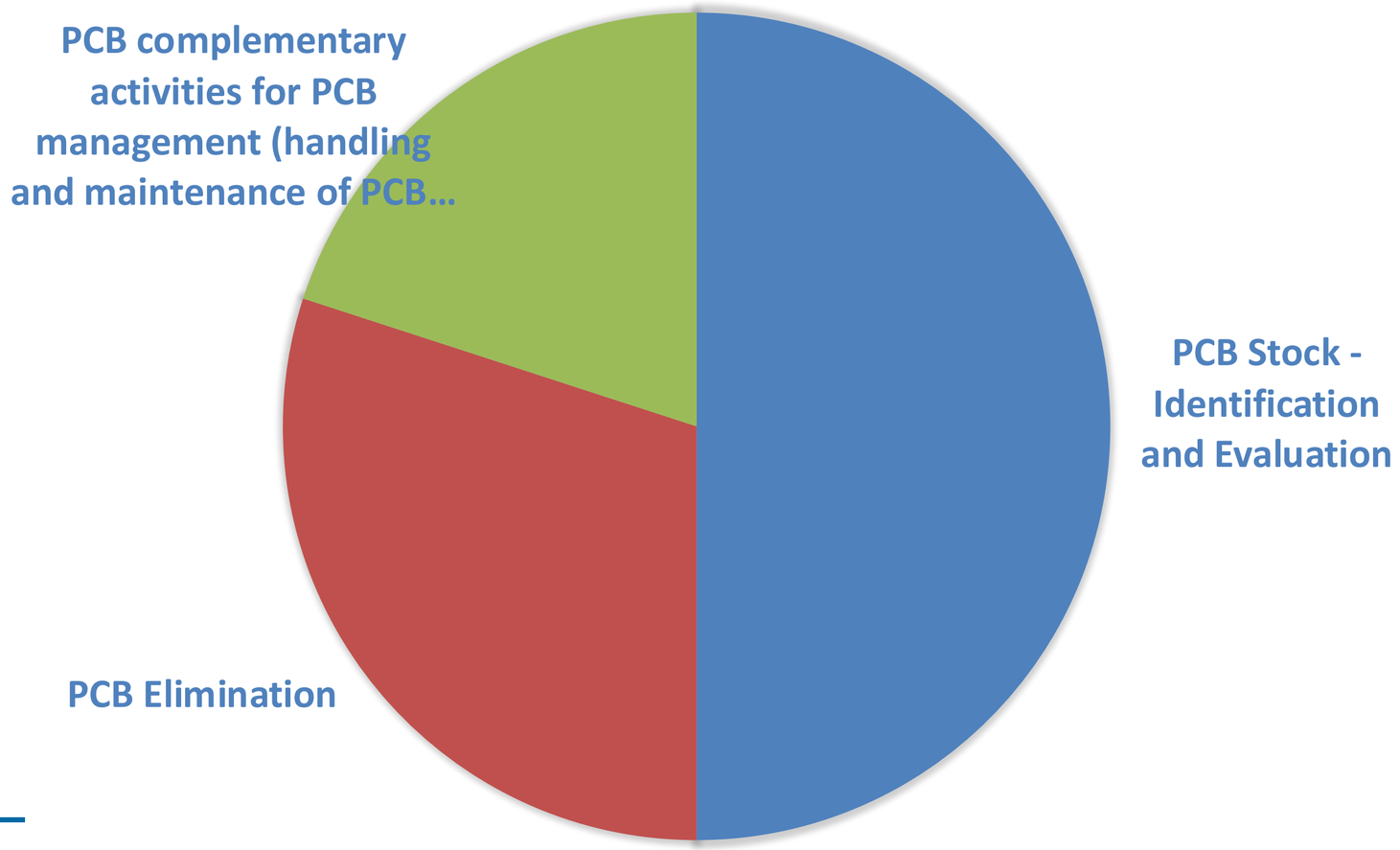
"Making visible the legacy of Polychlorinated Biphenyls (PCBs): Regional Webinar " Towards the 2025 and 2028 goals under the Stockholm Convention

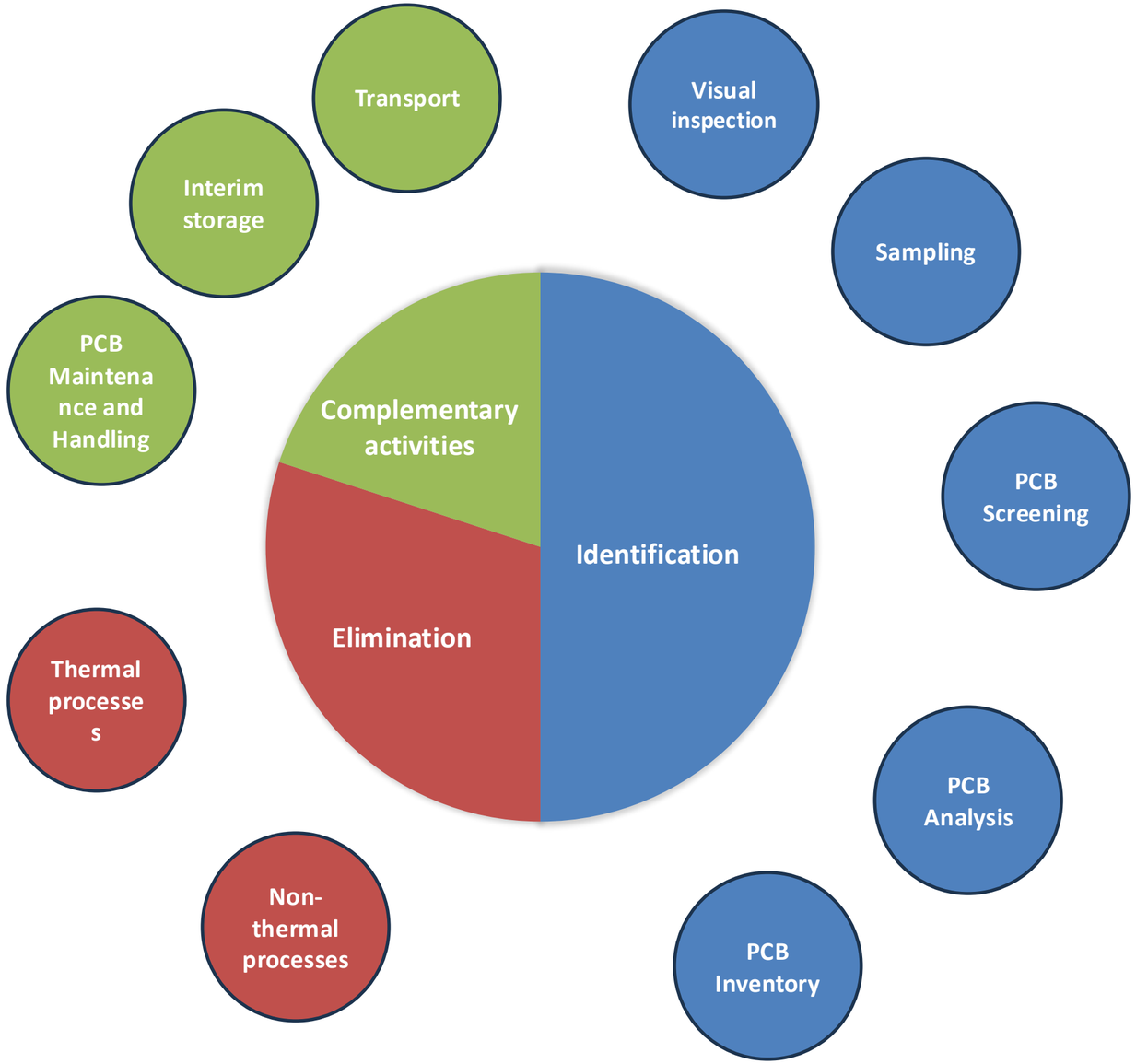
September 2025

Phases of PCB Environmentally Sound Management



Specific activities

According to PCB life cycles phases



PCB sources and the main challenges in the region

Sources

- Oil leakage
- Wrongly disposed of transformers
- Import of e-waste
- Open burning
- Performing activities with transformers without adequate measures of protection
- Many countries store PCB stockpiles in open fields.
- Cross-contamination

Challenges

- Some PCB inventories are inconsistent and incomplete.
- Transformers contaminated with PCBs are operated and managed without the appropriate procedures.
- There are several PCB-contaminated sites
- There are no assessments regarding the PCB impact on human health

Gioia, R., Akindele, A.J., Adebusoye, S.A. et al. Polychlorinated biphenyls (PCBs) in Africa: a review of environmental levels. Environ Sci Pollut Re 21, 6278–6289 (2014). https://doi.org/10.1007/s11356-013-1739-1.
Sisay Abebe Debela, Ishmail Sheriff, Girma Garedew Goyomsa, Ashenafi Teshome Guta, Mesfin Gebrehiwot. Management of polychlorinated biphenyls stockpiles and contaminated sites in Africa: A review of 34 countries


3432


JCB

PCB identification

BASEL | ROTTERDAM | STOCKHOLM CONVENTIONS

unitar United Nations Institute for Training and Research

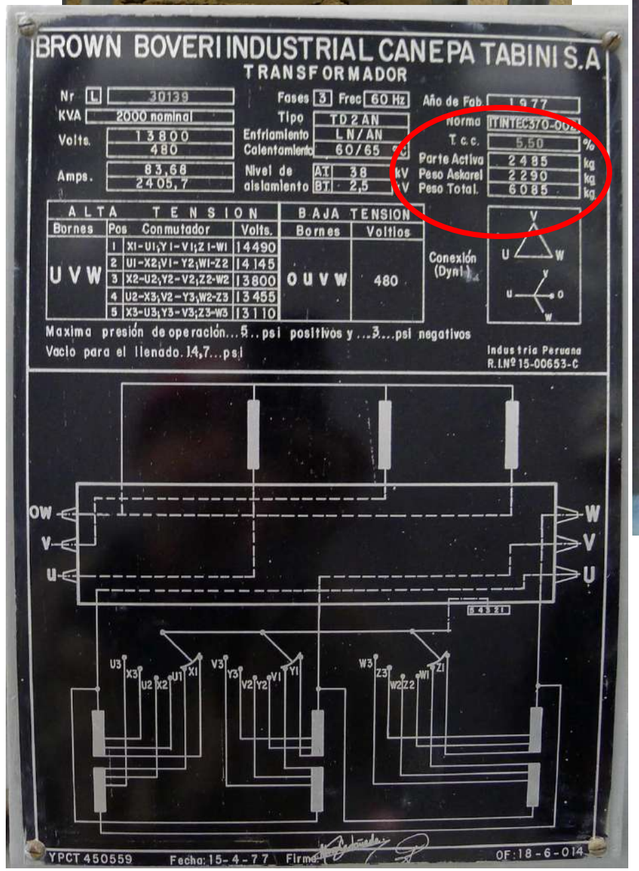
Visual Inspection (1)

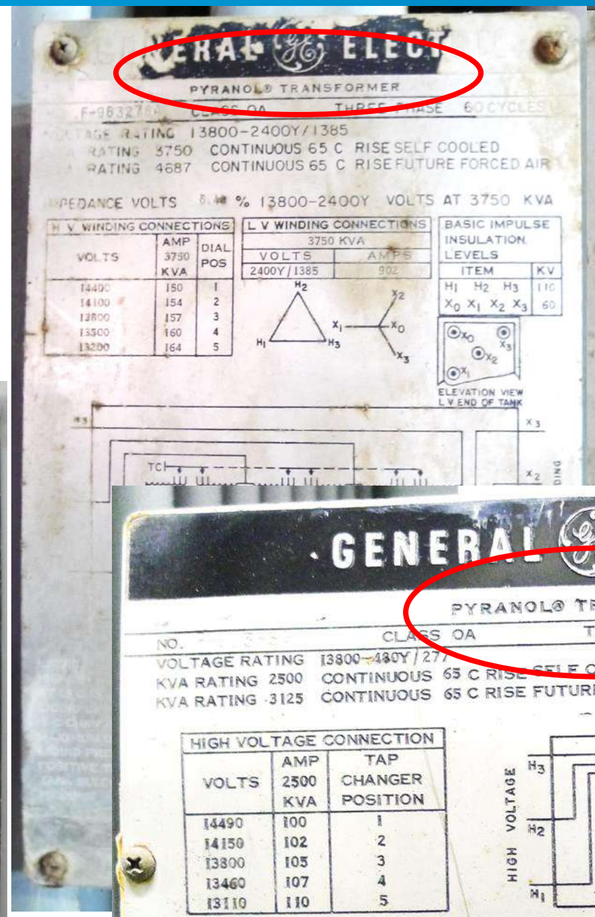
Verify through the manufacturing plate and the existence of evidence that the equipment has not been subjected to maintenance that impacts the quality of the dielectric oil

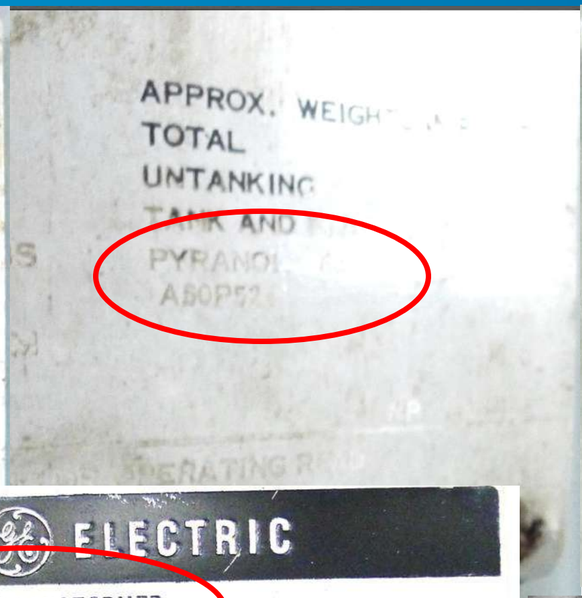
Activity	Best practices	In the field
Visual Inspection	Verify the technical characteristics as listed on the manufacturer's plate. UNEP/POPS/COP.12/INF/10 (p14)	There are no manufacturer's plates, in poor condition, or with errors in the registration, resulting in an inconsistent database.
	Analyze equipment maintenance history UNEP/POPS/COP.12/INF/10 (p14)	No record of maintenance available.
	The database must contain accurate information about the company's equipment UNEP/POPS/COP.12/INF/10 (p18)	There is no correlation between the database and the real data in the field.

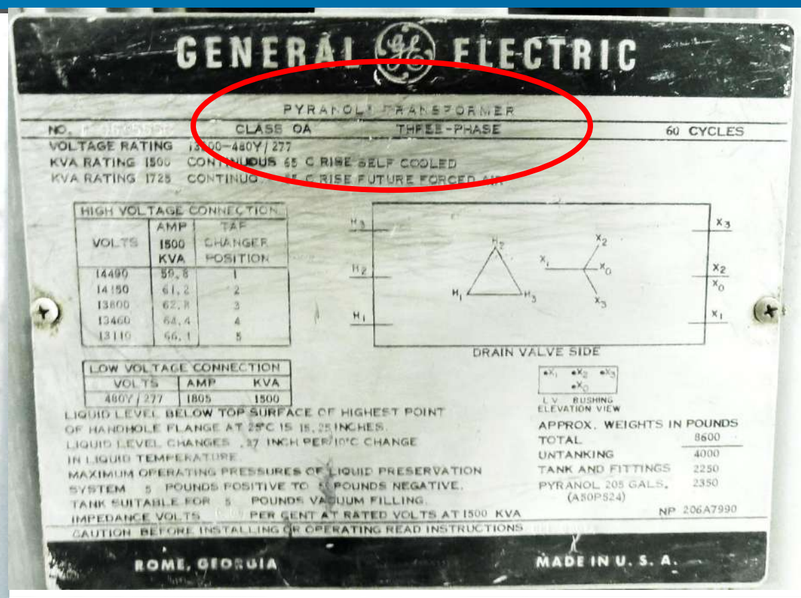
(1). Concept and commercial labels for the communication of Polychlorinated Biphenyl (PCB) content according to EPA 40 CFR Part 761 – Guidance for the development of Polychlorinated Biphelys (PCB) inventories and determination of PCB content – UNEP/POPS/COP.12/INF/10(p.13, 14).

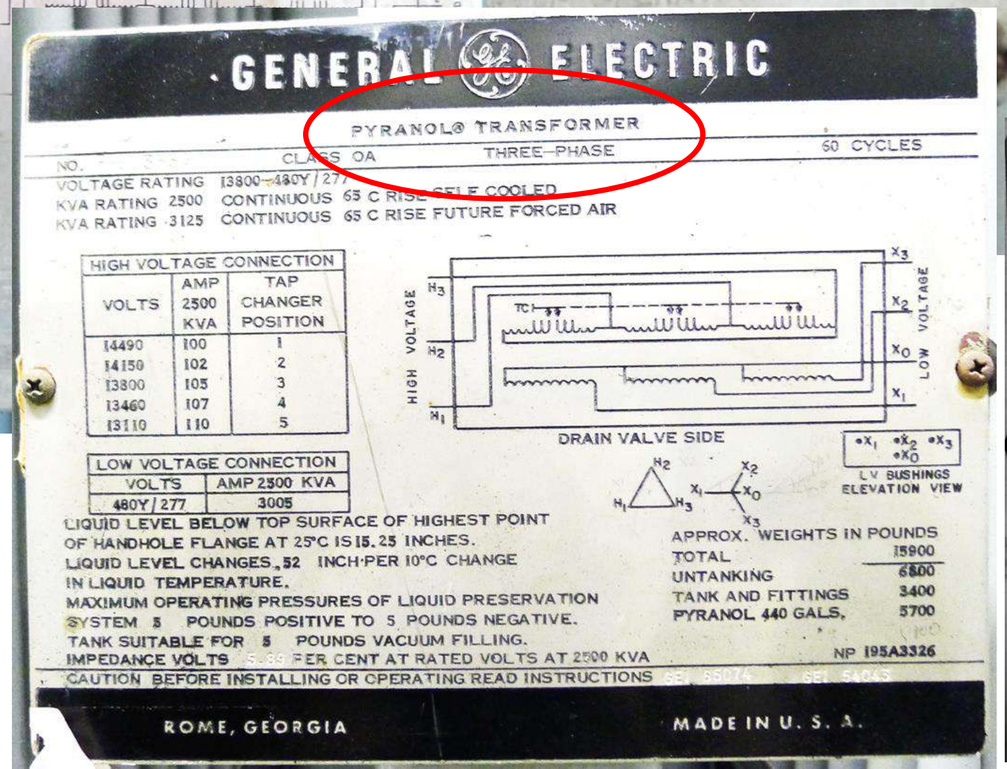

No PCB's

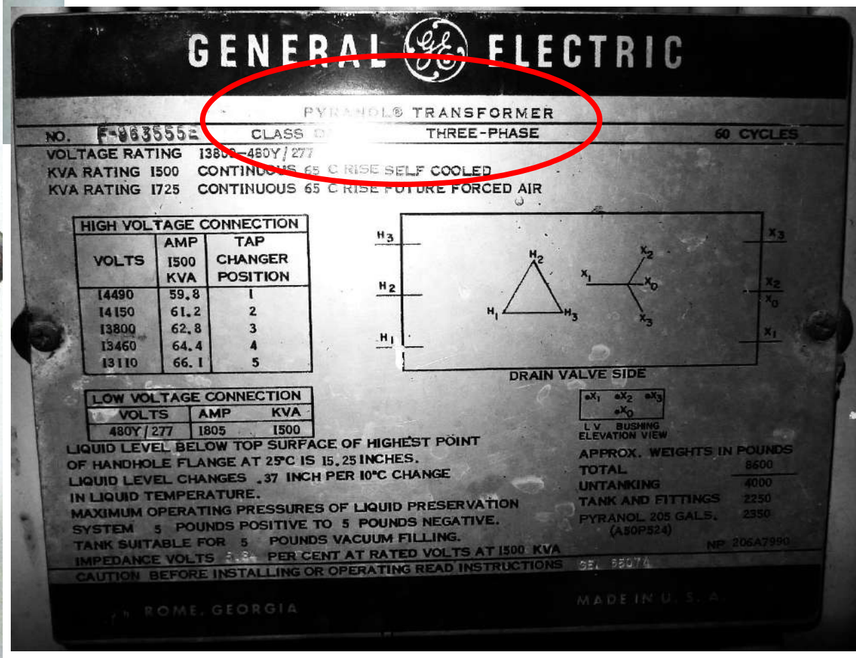

BROWN BOVERI INDUSTRIAL CANEPA TABINI S.A
TRANSFORMADOR
Nr L 30139
KVA 2000 nominal
Volts. 13800 480
Amps. 83,68 2405,7
Fases 3 Frec 60 Hz
Tipo TD 2 AN
Enfriamiento LN/AN
Calentamiento 60/65 °C
Nivel de aislamiento AT 38 kV BT 2,5 kV
Año de Fab. 1977
Norma ITINTEC 370-005
T. c. c. 5,50 %
Parte Activa 2485 kg
Peso Askarel 2290 kg
Peso Total. 6085 kg
ALTA TENSION
Bornes Pos Conmutador Volts.
U V W 1 X1-U1;Y1-V1;Z1-W1 14490
2 U1-X2;V1-Y2;W1-Z2 14145
3 X2-U2;Y2-V2;Z2-W2 13800
4 U2-X3;V2-Y3;W2-Z3 13455
5 X3-U3;Y3-V3;Z3-W3 13110
BAJA TENSION
Bornes Voltios
O U V W 480
Conexión (Dyn1)
Maxima presión de operación...5...psi positivos y ...3...psi negativos
Vacio para el llenado. 14,7...psi
Industria Peruana
R.I.N° 15-00653-C
OW V U
W V U
U3 X3 U2 X2 U1 X1 V3 Y3 V2 Y2 V1 Y1 W3 Z3 W2 Z2 W1 Z1
YPCT 450559 Fecha: 15-4-77 Firma:
OF: 18-6-014


PYRANOL® TRANSFORMER
CLASS OA THREE-PHASE 60 CYCLES
VOLTAGE RATING 13800-2400Y/1385
KVA RATING 3750 CONTINUOUS 65 C RISE SELF COOLED
KVA RATING 4687 CONTINUOUS 65 C RISE FUTURE FORCED AIR
IMPEDANCE VOLTS % 13800-2400Y VOLTS AT 3750 KVA
H.V. WINDING CONNECTIONS
VOLTS AMP 3750 KVA DIAL POS
14400 150 1
14100 154 2
13800 157 3
13500 160 4
13200 164 5
L.V. WINDING CONNECTIONS
3750 KVA
VOLTS AMPS
2400Y/1385 902
BASIC IMPULSE INSULATION LEVELS
ITEM KV
H1 H2 H3 110
X0 X1 X2 X3 60
ELEVATION VIEW L.V. END OF TANK
TC


APPROX. WEIGHT
TOTAL
UNTANKING
TANK AND
PYRANOL


GENERAL ELECTRIC
PYRANOL® TRANSFORMER
NO. CLASS OA THREE-PHASE 60 CYCLES
VOLTAGE RATING 13800-480Y/277
KVA RATING 1500 CONTINUOUS 65 C RISE SELF COOLED
KVA RATING 1725 CONTINUOUS 65 C RISE FUTURE FORCED AIR
HIGH VOLTAGE CONNECTION
VOLTS AMP 1500 KVA TAP CHANGER POSITION
14490 59,8 1
14150 61,2 2
13800 62,8 3
13460 64,4 4
13110 66,1 5
DRAIN VALVE SIDE
LOW VOLTAGE CONNECTION
VOLTS AMP KVA
480Y/277 1805 1500
L.V. BUSHING ELEVATION VIEW
LIQUID LEVEL BELOW TOP SURFACE OF HIGHEST POINT OF HANDHOLE FLANGE AT 25°C IS 15.25 INCHES.
LIQUID LEVEL CHANGES .37 INCH PER 10°C CHANGE IN LIQUID TEMPERATURE.
MAXIMUM OPERATING PRESSURES OF LIQUID PRESERVATION SYSTEM 5 POUNDS POSITIVE TO 5 POUNDS NEGATIVE.
TANK SUITABLE FOR 5 POUNDS VACUUM FILLING.
IMPEDANCE VOLTS PER CENT AT RATED VOLTS AT 1500 KVA
CAUTION BEFORE INSTALLING OR OPERATING READ INSTRUCTIONS
APPROX. WEIGHTS IN POUNDS
TOTAL 8600
UNTANKING 4000
TANK AND FITTINGS 2250
PYRANOL 205 GALS. (A50P524) 2350
NP 206A7990
ROME, GEORGIA
MADE IN U. S. A.


GENERAL ELECTRIC
PYRANOL® TRANSFORMER
NO. CLASS OA THREE-PHASE 60 CYCLES
VOLTAGE RATING 13800-480Y/277
KVA RATING 2500 CONTINUOUS 65 C RISE SELF COOLED
KVA RATING 3125 CONTINUOUS 65 C RISE FUTURE FORCED AIR
HIGH VOLTAGE CONNECTION
VOLTS AMP 2500 KVA TAP CHANGER POSITION
14490 100 1
14150 102 2
13800 105 3
13460 107 4
13110 110 5
HIGH VOLTAGE
LOW VOLTAGE
TC
DRAIN VALVE SIDE
LOW VOLTAGE CONNECTION
VOLTS AMP 2500 KVA
480Y/277 3005
L.V. BUSHINGS ELEVATION VIEW
LIQUID LEVEL BELOW TOP SURFACE OF HIGHEST POINT OF HANDHOLE FLANGE AT 25°C IS 15.25 INCHES.
LIQUID LEVEL CHANGES .52 INCH PER 10°C CHANGE IN LIQUID TEMPERATURE.
MAXIMUM OPERATING PRESSURES OF LIQUID PRESERVATION SYSTEM 5 POUNDS POSITIVE TO 5 POUNDS NEGATIVE.
TANK SUITABLE FOR 5 POUNDS VACUUM FILLING.
IMPEDANCE VOLTS PER CENT AT RATED VOLTS AT 2500 KVA
CAUTION BEFORE INSTALLING OR OPERATING READ INSTRUCTIONS
APPROX. WEIGHTS IN POUNDS
TOTAL 15900
UNTANKING 6800
TANK AND FITTINGS 3400
PYRANOL 440 GALS. 5700
NP 195A3326
ROME, GEORGIA
MADE IN U. S. A.


GENERAL ELECTRIC
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HIGH VOLTAGE CONNECTION
VOLTS AMP 1500 KVA TAP CHANGER POSITION
14490 59,8 1
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13460 64,4 4
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DRAIN VALVE SIDE
LOW VOLTAGE CONNECTION
VOLTS AMP KVA
480Y/277 1805 1500
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LIQUID LEVEL BELOW TOP SURFACE OF HIGHEST POINT OF HANDHOLE FLANGE AT 25°C IS 15.25 INCHES.
LIQUID LEVEL CHANGES .37 INCH PER 10°C CHANGE IN LIQUID TEMPERATURE.
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TANK AND FITTINGS 2250
PYRANOL 205 GALS. (A50P524) 2350
NP 206A7990
ROME, GEORGIA
MADE IN U. S. A.

Sampling

- Oil in transformers
- Contaminated sites
- Surfaces and water

Energized Equipment
Non-energized equipment
Equipment in waste quality

Activity	Best practices	In the field
Sampling	Take safety measures UNEP/POPS/COP.12/INF/10 (23)	There are not always PPE safety measures, etc.
	Registration of technical data (Manufacturing plate, Patrimonial Registry or express identification) UNEP/POPS/COP.12/INF/10 (18)	Sometimes, the technician applies different criteria to interpret the information, which can create confusion or inconsistency.
	Sample tagged with complete sample origin data (chain of custody development) UNEP/POPS/COP.12/INF/10 (23)	There are errors during registration, and there was no good practice in sample management. So there is data lost.
	Involve Authorities in the development of viable alternatives to suspend services during PCB management activities UNEP/POPS/COP.12/INF/11 (p 8)	Lack of administrative or legal mechanisms for electrical supply interruption due to oil sampling in transformers in service.

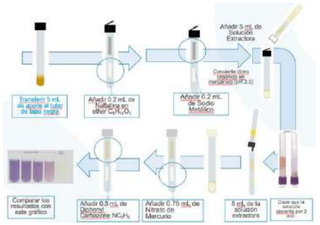
Fotos : UNIDO Project “Environmentally Sound Management and Disposal of Polychlorinated biphenyls (PCBs)”, Peru – 2014. UNITAR soil samples extraction in Paraguay

PCB Management in Ethiopia to meet the 2025 Stockholm Convention Deadline - Phase 1

PCB Screening

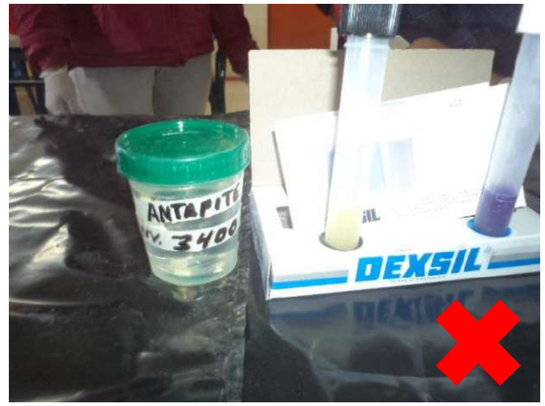
Colorimetric method



Electrochemical Measurement


Activity	Best practices (1)	In the field
PCB Screening	Verify the validity of reagents	Loss of reagents due to expiration dates being exceeded
	Proper sample preparation	Inadequate sample preparation
	PCB Screening Report Preparation	Lack of Screening Report or factual evidence of the result (print, photo)



(1) EPA Method 9079

Fotos: UNITAR, training activities in "*Capacity Building for Poly-Chlorinated Biphenyls (PCBs) and Unintentional Persistent Organic Pollutants (UPOPs) in The Gambia' (PIMS # 5908, GEF ID 9570)* project.
UNITAR training sessions "Strengthening for the Management and Elimination of PCBs in Paraguay".

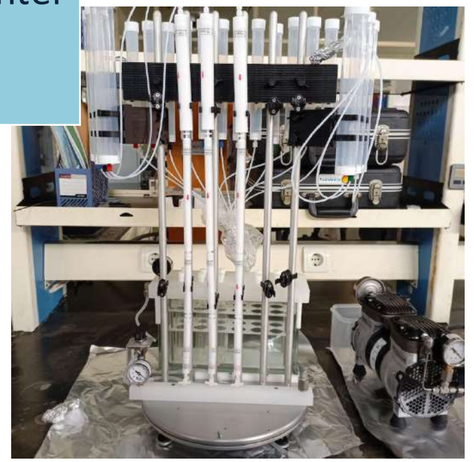
PCB Analysis

Activity	Best practices	In the field
PCB Analysis	Accredited laboratories and, if possible, with satisfactory results in interlaboratories.	Not enough accredited labs or a lack of practices of inter-laboratory for PCBs

Gas chromatography

Arochlores - ASTM D4059–-00(2018)
1242
1254
1260

Indicators
PCB 28
PCB 52
PCB101
PCB 138
PCB 153
PCB180



(1): Revised strategy for Parties to meet the 2025 and 2028 goals on polychlorinated biphenyls of the Stockholm Convention - UNEP/POPS/COP.12/INF/11 (p 9)
Guidance for the development of Polychlorinated Biphelys (PCB) inventories and determination of PCB content – UNEP/POPS/COP.12/INF/10 (p.26).

PCB Inventory

PCB Equipment

Waste
(oil, soil, metals, etc.)

Facilities
(workshops, warehouses, administrative offices)

Activity	Best practices	In the field
PCB Inventory	A preliminary inventory can be obtained by inspecting equipment suspected of containing PCBs UNEP/POPS/COP.12/INF/10 (p12)	Difficulties in achieving a reliable and up-to-date of the company equipment database.
	Label PCB Verified Equipment with CG Results UNEP/POPS/COP.12/INF/11 (p 9)	Sometimes, PCB equipment is not labeled because it is removed or moved without proper registration or tracking.
	Update and maintain PCB inventories (e.g. after maintenance - suspected cross-contamination UNEP/POPS/COP.12/INF/11 (p 9)	They do not apply pre- and post-maintenance control to avoid cross-contamination.
	The PCB inventory should contain all relevant and accurate equipment information. UNEP/POPS/COP.12/INF/10 (P18)	Inconsistent database, lacking the main information to make the best decisions.
	Randomly sampling (representative sample) and analyzing equipment that was classified PCB-free UNEP/POPS/COP.12/INF/10 (p22)	Companies do not record maintenance activities or are not very accurate.

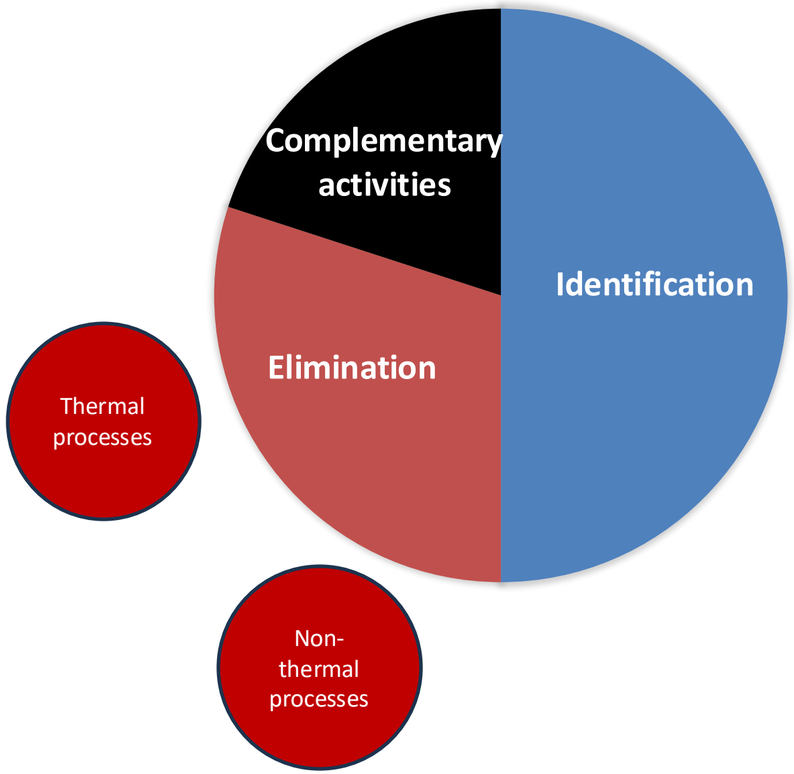
UNITAR, PCB Inventory - "Strengthening for the Management and Elimination of PCBs in Paraguay".

Determination procedure	Code	Reference	Scope	Instrumental Technique	Rank	Results Report
Visual inspection (nameplate reading) (R)	R1	PCB Trade Name, Year of Manufacture, Cooling Code, Maintenance Records	Equipment	--	PCB Equipment / Non-PCB Equipment / Inconclusive	PCB Trade Name (PCB Presence)
Screening - Semi-Quantitative Analysis (S)	S1	USEPA 9079 -	Petroleum-based transformer oils	Colorimetric indicator	20, 50, 100 or 500 µg/g	Total PCB
	S2	Instruction Manual	Samples of soil, water, transformer oil, or surface wipes	Potentiometric test. PCB Analyzer (Analyzer L2000DXT)	All types of chlorinated hydrocarbons, including PCBs (3 to 2000 mg/kg)	Total PCB
Confirmatory Analysis - Quantitative (C)	C1	CEN (EN 12766-1, EN 12766-2 and EN 12766-3)	Petroleum products and synthetic lubricating oils	GC/ECD	Applicable	6 PCB Indicator[1] and PCB total
	C2	IEC Method 61619:1997 'Insulating Liquids	Used oil and insulating fluids	HRGC/ECD	Applicable	6 PCB Indicator[1] and PCB total
	C3	ASTM D4059-00	Insulating fluids - transformer oil	GC/ECD	Applicable	Sum of the Aroclores[2]
Confirmatory Analysis of Environmental Matrices - Quantitative (D)	D1	USEPA 8082A	Solid Matrices (Soil Sample)	GC/ECD	Applicable	PCBs as Aroclors or as individual PCB congeners[3]
	D2	USEPA 1668	Wastewater, surface water, soils, sediments, biosolids, and tissue matrices	GC/MS HRGC/HRMS	Applicable	12 dioxins as PCB and PCB[4] total

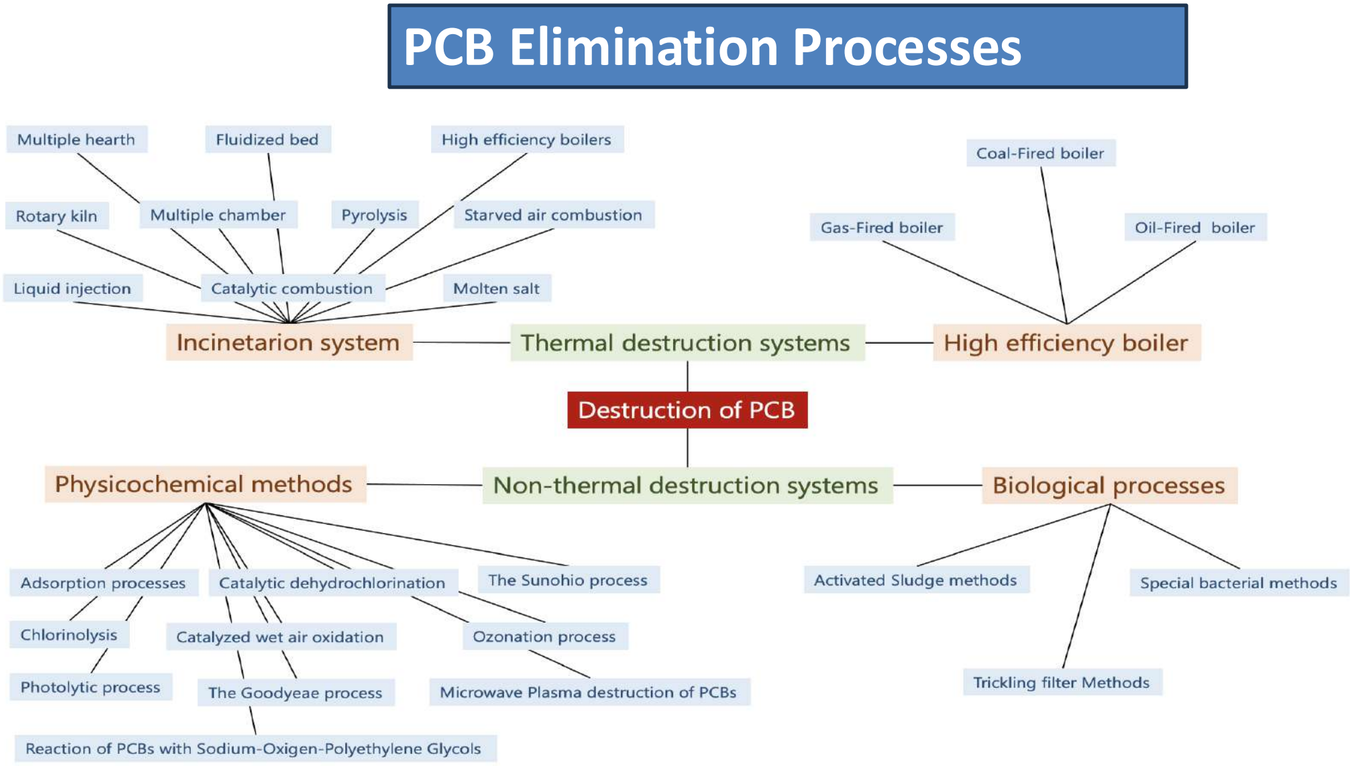
[1] PCB 28, 52, 101, 138, 153 and 180 (the final result is calculated by sum of the six PCB multiplied by 5)
[2] The technique is based on data from the standard chromatograms of Aroclores 1242, 1254 and 1260
[3] Aroclor 1016, 1221, 1232, 1242, 1248, 1254, 1260 and PCBs 1, 5, 18, 31, 44, 52, 66, 87, 101, 110, 138, 141.
[4] 12 PCB congeners 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169 and 189

UNEP/POPS/COP.12/INF/10 – p28

PCB Elimination(1)



- Environmentally sound elimination
- Are disposed of in such a way that the PCB is “irreversibly” destroyed or transformed or its content is low, taking into account applicable rules, standards, and guidelines



(1) Stockholm Convention, Article 6(1)(d)(ii)

CHEMICAL ELIMINATION

RECLASSIFICATION

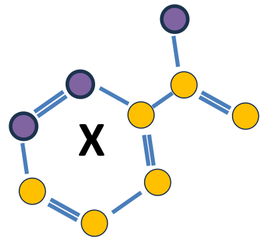
Replacement of dielectric oil to reduce the concentration in the equipment to below 50 ppm (maximum limit, 500 ppm)

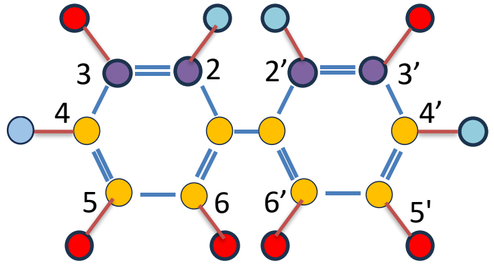
DECHLORINATION

PCB dechlorination is understood as a method of chemical removal by dehalogenating PCBs by radical-ionic reaction mechanisms, with or without catalysts, until the permitted concentration limit is reached or below it.

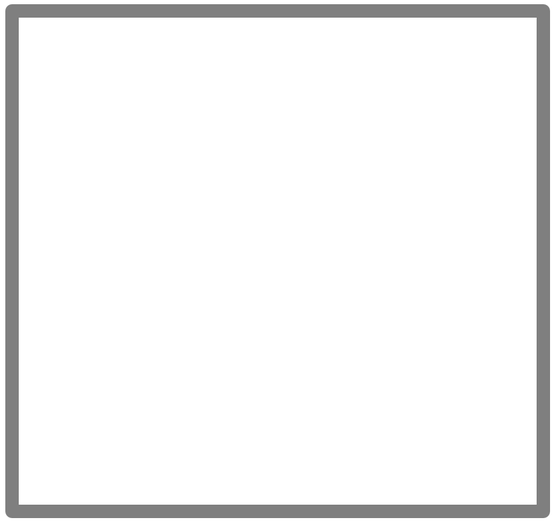
DESTRUCTION AND DECONTAMINATION TECHNOLOGIES FRO PCBs AND OTHER POPs WASTES UNDER THE BASEL CONVENTION - A Training Manual for Hazardous Waste Project Managers Annex C, Secretariat of the Basel Convention - UNEP

PCB ELIMINATION CHEMICAL PROCESS



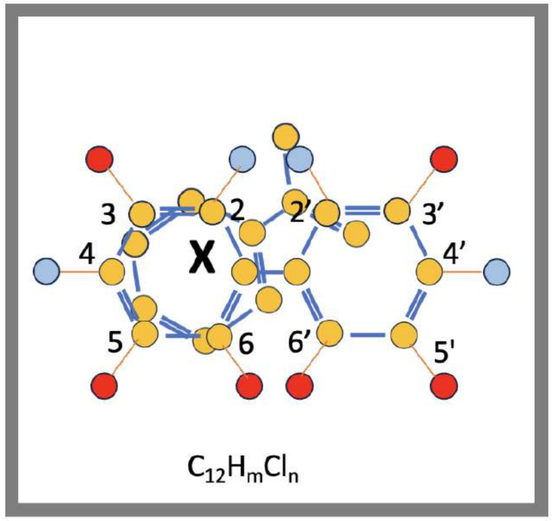


$C_{12}H_mCl_n$

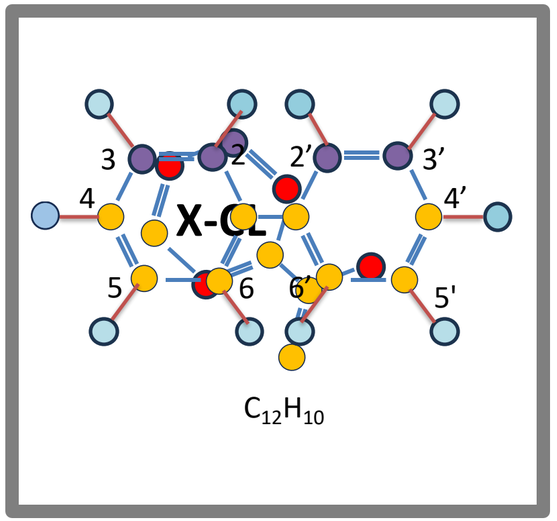


Reactor

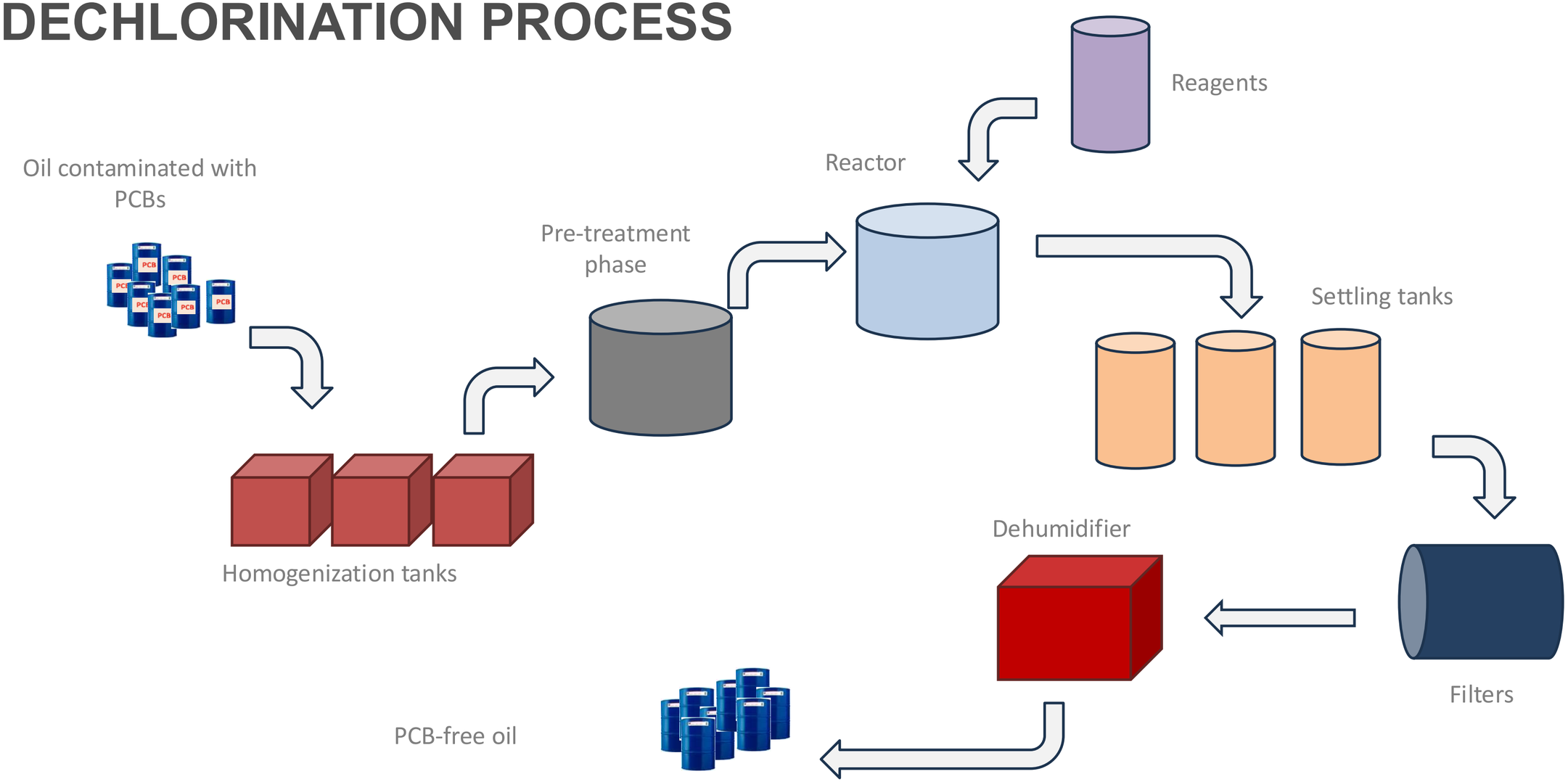
PCB ELIMINATION CHEMICAL PROCESS



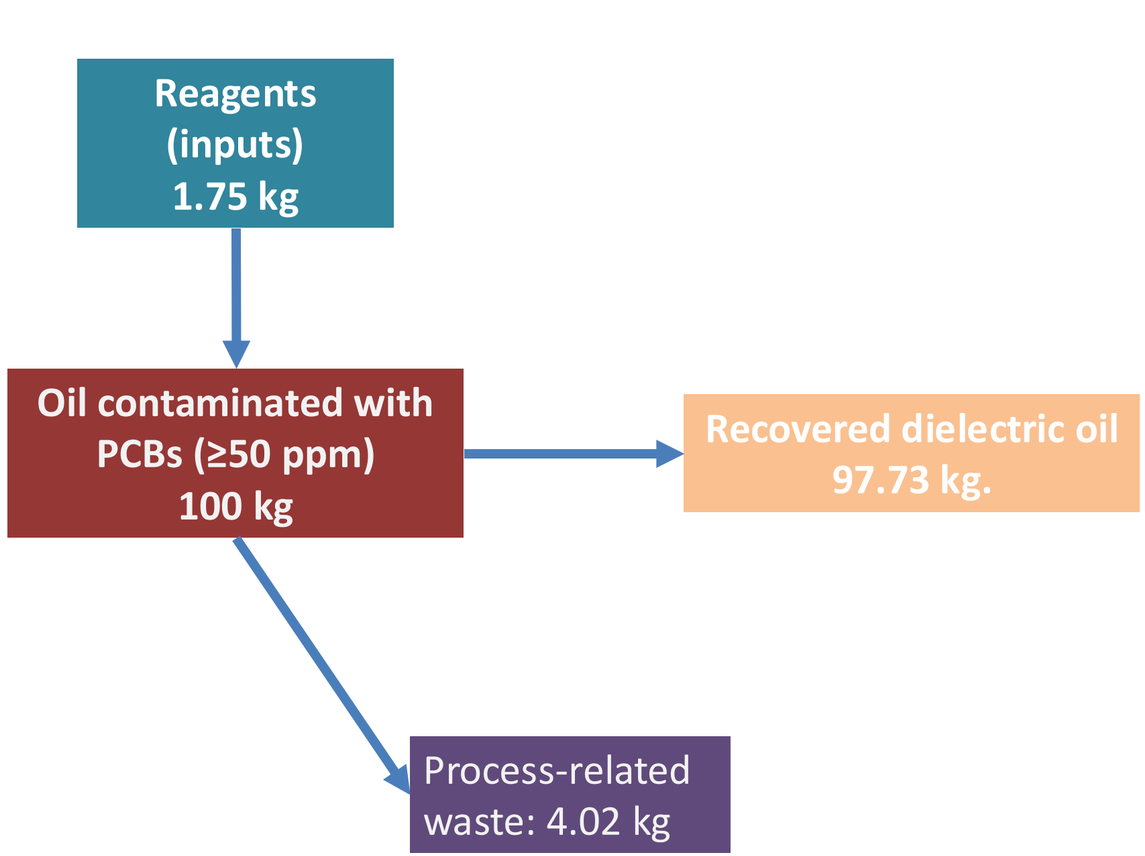
PCB ELIMINATION CHEMICAL PROCESS



DECHLORINATION PROCESS



Material flow during the dechlorination process



- Oil contaminated with PCBs: 98.28%
- Reagents (Sodium metallic): 0.54%
- Fuller Lands: 1.08%
- Antioxidant: 0.10%

Dechlorination Process

- PCB-free oil: 96.05%
- Solid Waste: 3.01%
- Settling residues (lees): 0.88%
- Other waste (PPE, solvents, rags): 0.06%

THERMAL PROCESSES

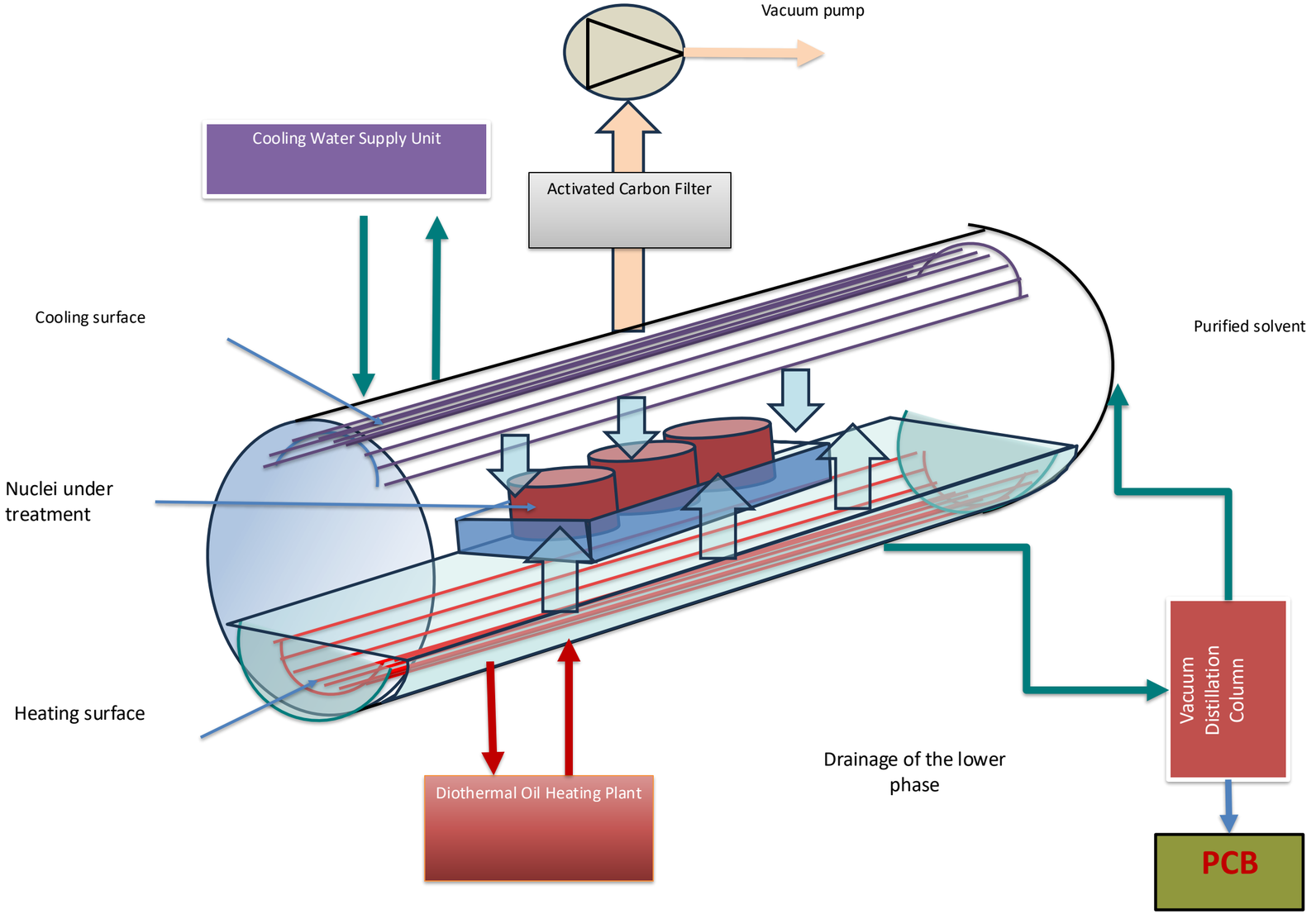
AUTOCLAVE

- Solvent decontamination process by extracting the PCB from contaminated material (housings, metal residues, etc.)
- It is used in combination with incineration (wood, paper, always oil). DRE 99.999%

HIGH TEMPERATURE PROCESSES

- PCB destruction by controlled combustion of time, temperature, and turbulence.
- Operating temperatures above 850 °C up to 10,000 ºC.
- Total destruction (99.9999%)
- Liquids, solid waste such as metals and soils (e.g. condensers) can be incinerated.

AUTOCLAVE DIAGRAM



INCINERATION

Hazardous waste incineration uses controlled flame combustion to destroy PCBs.

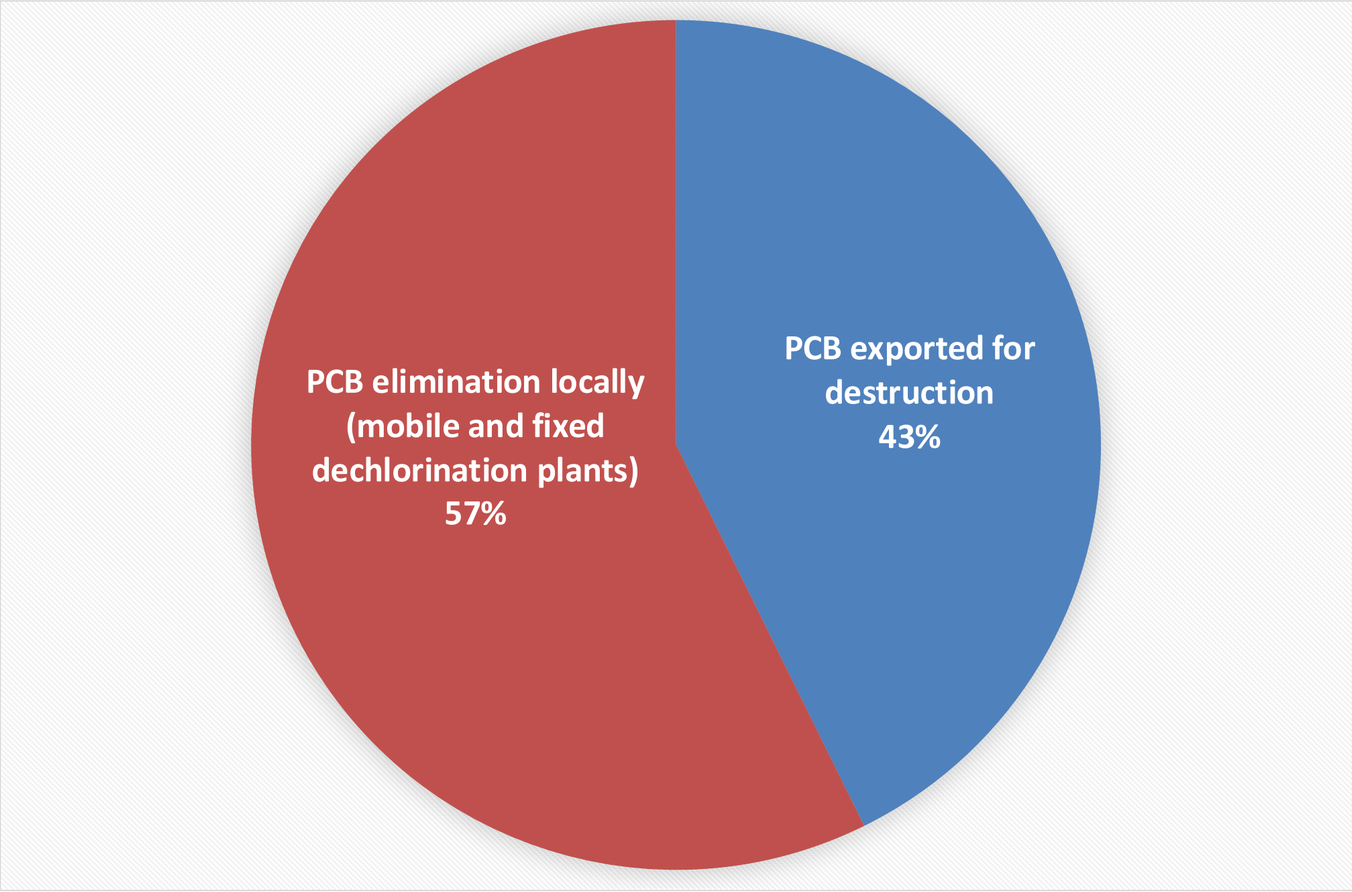
- They require good control of time, temperature and turbulence (3Ts).
- More than 850°C for 2-3 seconds to PCB destruction.
- Large capacity.
- Located in developed countries.
- Total Destruction (DR: 83.15 – 99.88%)

REF: There is a long experience with hazardous waste incineration. (UNEP, 2001, UNEP Draft 2004).

Destruction and decontamination technologies for PCBs and other POPs wastes under the Basel Convention (https://www.basel.int/Portals/4/Basel%20Convention/docs/meetings/sbc/workdoc/TM-C%20Annexes.pdf)

Shirco Electrical Infrared Incineration System at the Peak Oil Superfund Site: DRE: 99.99% DE: 83.15 – 99.88%

How are PCB being eliminated?



Report on progress towards the elimination of polychlorinated biphenyls, 18 April 2023, ASSESSMENT OF CAPACITIES FOR THE ENVIRONMENTAL MANAGEMENT OF PCB Towards the 2025 and 2028 Targets under the Stockholm Convention – PhD Rio Deswandi.

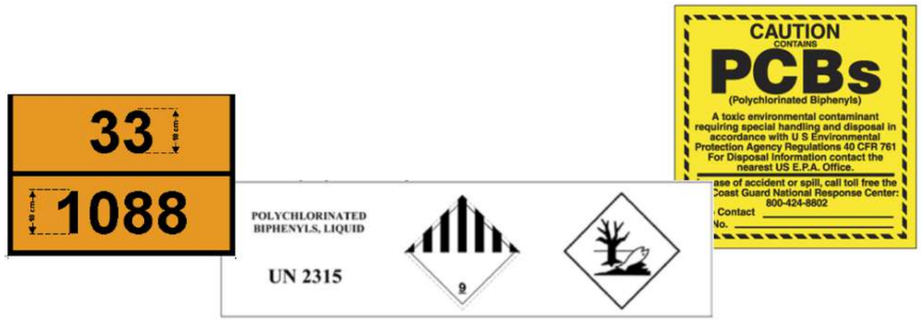
PCB Maintenance and Handling

- Systematic Method of PCB Control During Equipment Intervention
- Labeling of the equipment indicating its condition.
- Inform the staff about the associated risks and the necessary precautions and measures to be taken in the event of accidents.
- Check the waterproofness of the equipment periodically
- If a spill and dripping of the equipment occurs, remove it from service immediately, the oil must be removed from the equipment and store it in a safe place.
- Before and after performing maintenance or intervention on equipment that compromises the quality of the dielectric oil in relation to PCBs, a PCB discard test or analysis must be performed.
- Avoiding cross-contamination

Activity	Best practices	In the field
PCB Maintenance and Handling	Use of PPE	There are not always PPE safety measures, etc.
	Using PCB-specific equipment and tools and performing cleaning after maintenance	Tools and equipment are not intended for handling equipment with PCBs.
	Measures to Prevent PCB Cross-Contamination During Electrical Equipment Maintenance	Medium or small companies do not apply pre- and post-maintenance control to avoid cross-contamination.
	Involve and train personnel on risks in the handling of equipment that has equipment contaminated with PCBs.	Cross-contamination due to lack of training of handling equipment with PCBs

References:
Revised guidance for the development of polychlorinated biphenyl (PCB) inventories and the determination of PCB content
Revised strategy for Parties to meet the 2025 and 2028 goals on polychlorinated biphenyls of the Stockholm Convention

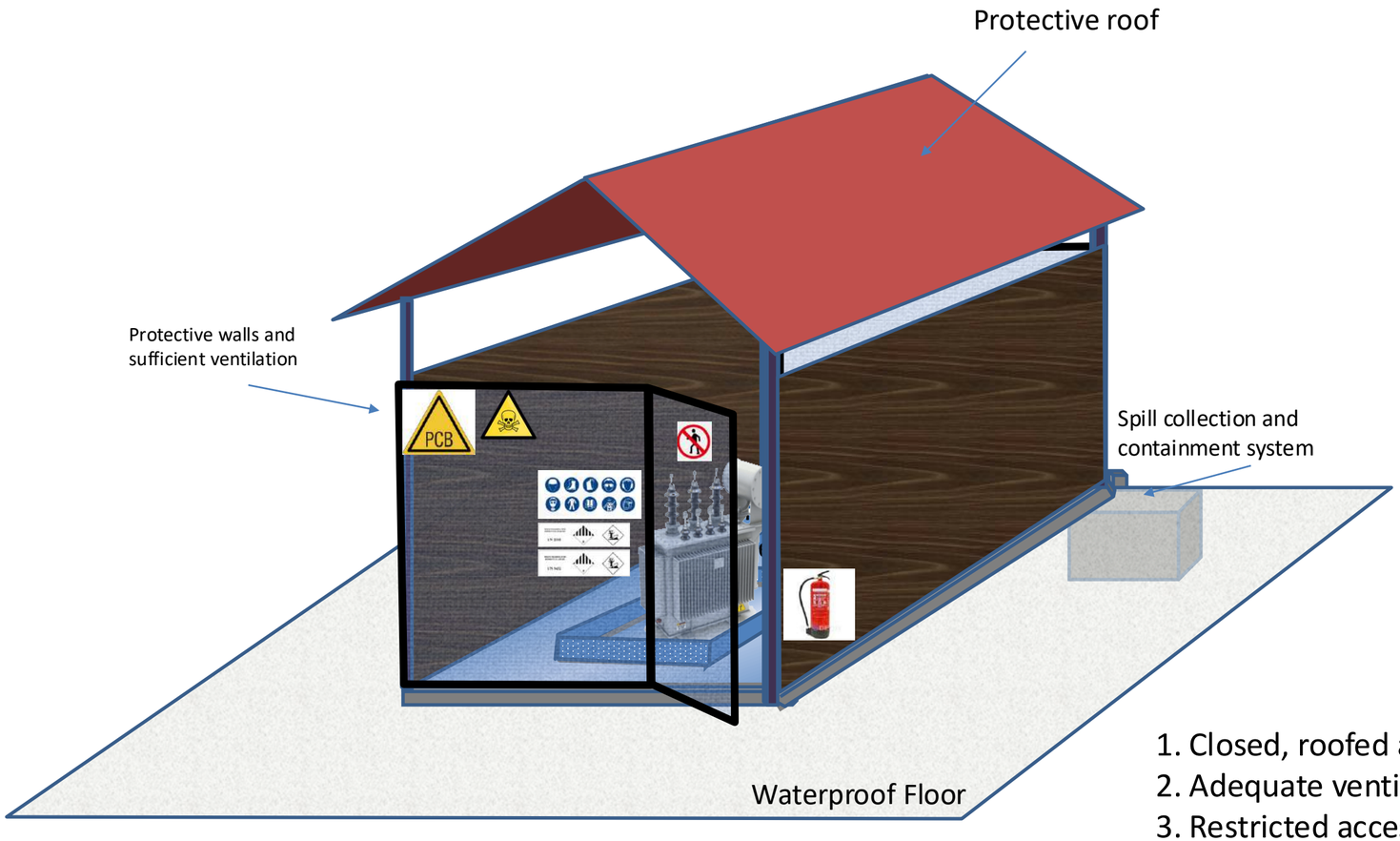
Safe Packaging and Transportation



AVOID ENVIRONMENTAL ACCIDENTS!

UNIDO Project “Environmentally Sound Management and Disposal of Polychlorinated biphenyls (PCBs)”, Peru – 2014.
PCB Management in Ethiopia to meet the 2025 Stockholm Convention Deadline - Phase 1

Interim storage



PCB interim storage activities must additionally meet local hazardous waste storage conditions and regulations

1. Closed, roofed and waterproof;
2. Adequate ventilation;
3. Restricted access, signage and security;
4. Leak and spill containment system;
5. Waterproof and fluid-proof floors;
6. Fire protection and control system.

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Thank you!

Global and regional experiences and best practices for the Environmentally Sound Management (ESM) of PCBs

Mario Mendoza
PCB Expert