Environmental Sound Management (ESM) of PCBs

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

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ABOUT ME

30 years experience in Haz Waste with focus on PCB & POPs

Focus:

- Disposal and Decontamination Technologies for polluted assets and soils
- Power Sector Maintenance Hight Tech Services
- Energy & Environment Dbase Management by AI

Roles
- Corporates & Startups Consultant
- UNDP Nigeria PCB Sound Management Project Auditor for Delivering & Commissioning of a stationary decontamination/dechlorination facility

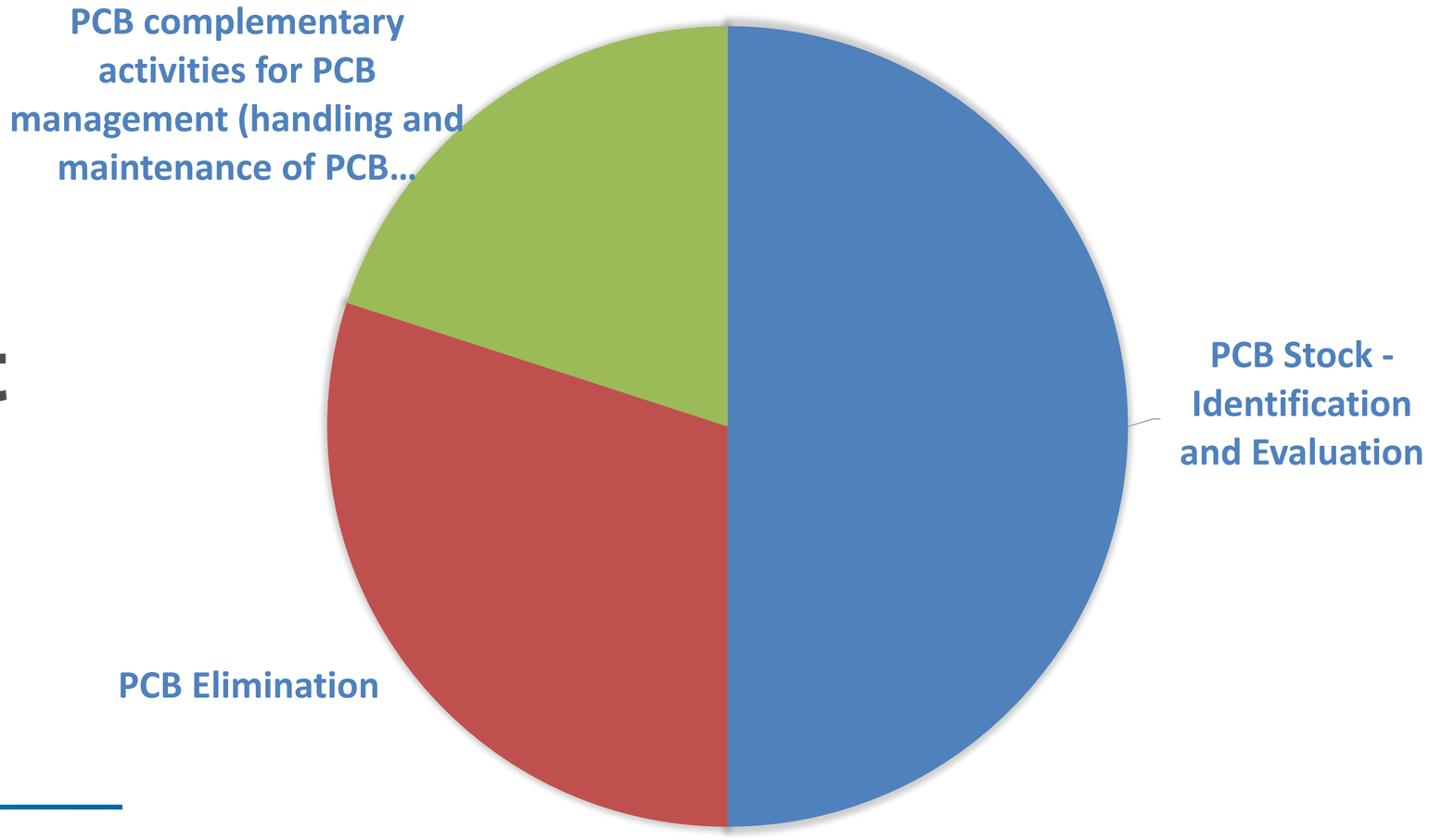
CONTENT

01. Strategies and programs to eliminate the use and disposal of PCBs: challenges and best solutions globally; regional example

02. Update and validation of PCB inventories: challenges and best solutions globally; regional example

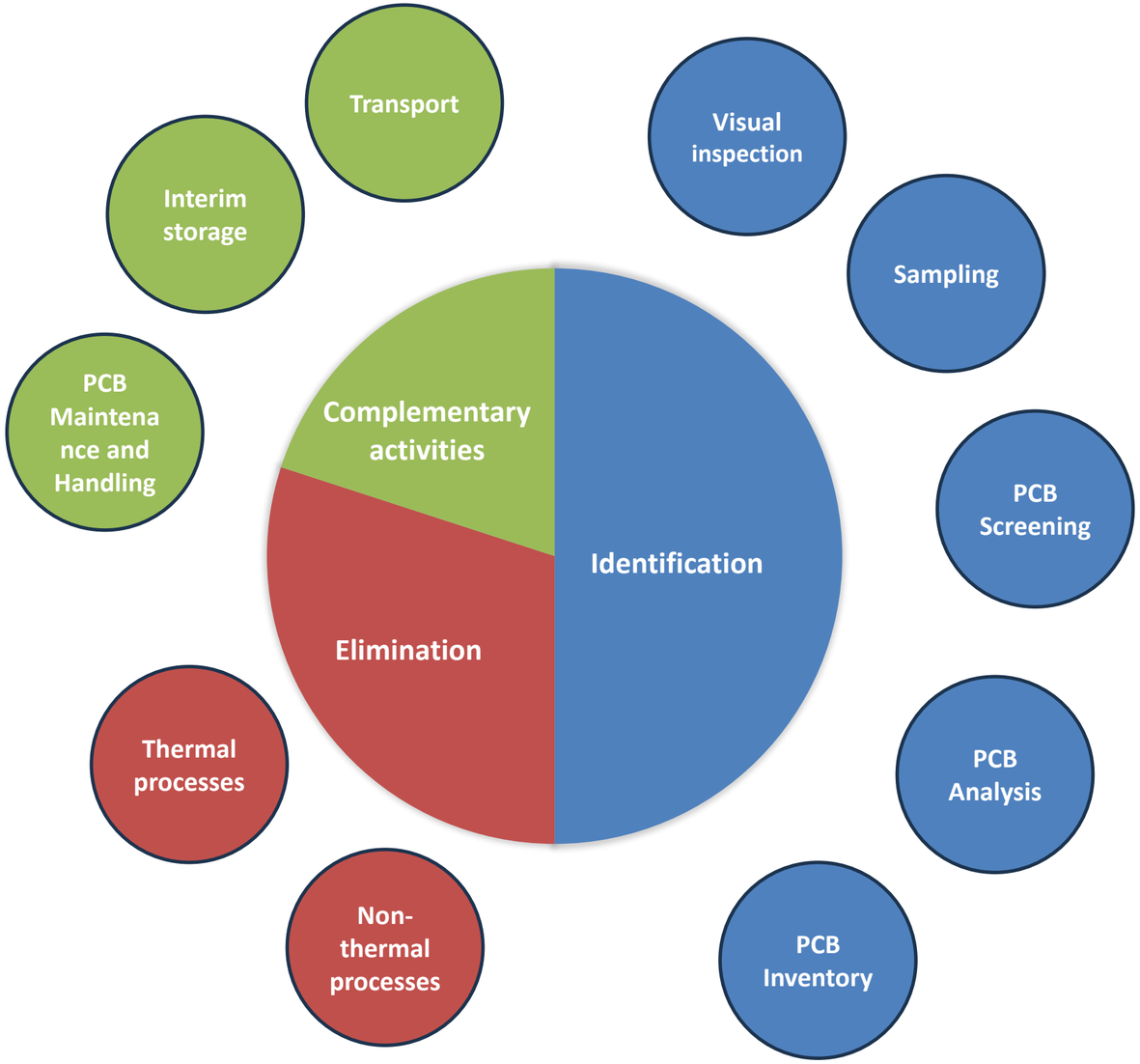
03. Capacities for environmental management of PCBs: PCBs treatment, decontamination and disposal technologies: global and regional example

Phases of PCB Environmentally Sound Management



Specific activities

According to PCB life cycles phases



PCB sources and main challenges

Sources

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

Challenges

- Some stakeholders' databases are inconsistent and incomplete.
- Transformers contaminated with PCBs are operated and managed without the appropriate procedures.
- There are several PCB-contaminated sites

Europe's Specific Patterns

- PCB OEM in West Europe and former USSR
- Decontamination plans acting since early '2000 or before
- EU open transboundary market for goods, wastes, techs
- Strong presence of PCB elimination companies
- Strong presence of accreditated Labs

- PCB polluted soils as an underestimated and neglected matter
- General positive trends in reducing number of contaminated PCB assets
- Logistics and permits handling is generally easier than other world areas
- Reasonable pricing policies and quite satisfactory level of quality service and environmental compliance

POTENTIAL PCB CONTAMINATED ITEMS IN POWER SECTOR (closed applications)

PCB concentration normally opposite of size

P

- Power
- Transfo

C

- Distribution
- Transfos

B

- Capacitors
- Switchgear, Breakers

IDENTIFICATION

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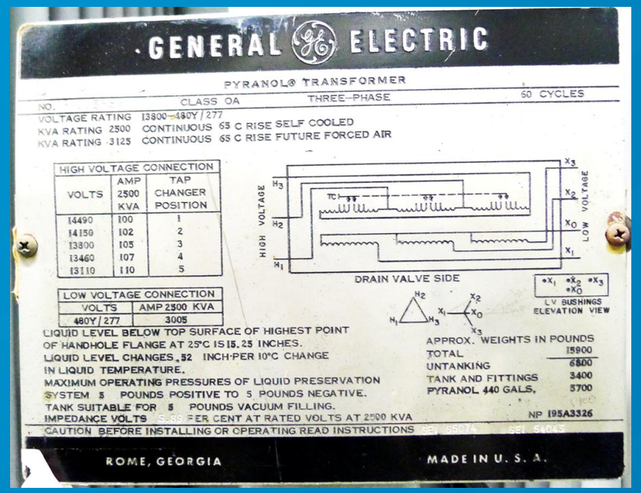
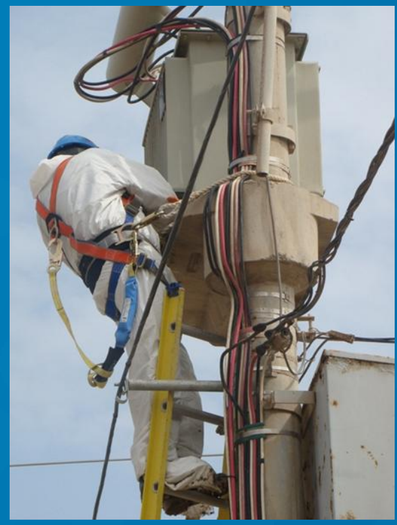
Visual Inspection



Data Collection

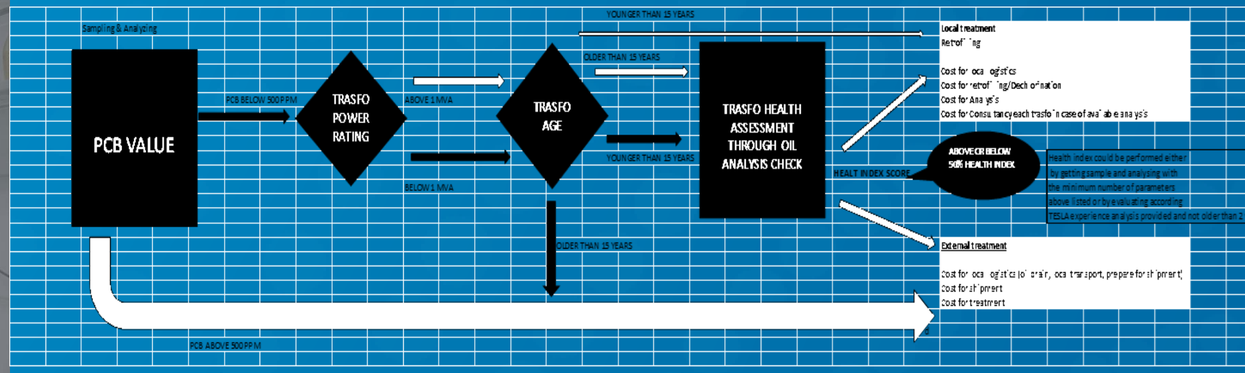


Sampling

IDENTIFICATION

Screening

Analysis



Data Elaboration

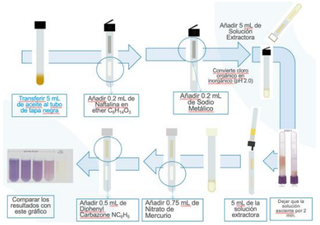
Determination procedure	Code	Reference	Scope	Instrumental Technique	Rank	Results Report
Visual inspection (nameplate reading) (R)	R1	PCB Trade Name, Year of Manufacture, Cooling Code, Maintenance Records	Equipment	--	PCB Equipment / Non-PCB Equipment / Inconclusive	PCB Trade Name (PCB Presence)
Screening - 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 Screening

Colorimetric method



Electrochemical Measurement

Activity	Best practices (1)	remarks
PCB Screening	Verify the validity of reagents	Values above 50 mg/kg to gaschromatograph
	Proper sample preparation	False positive/negative issues
	PCB Screening Report Preparation	External contamination

Providers from USA & EU

(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".

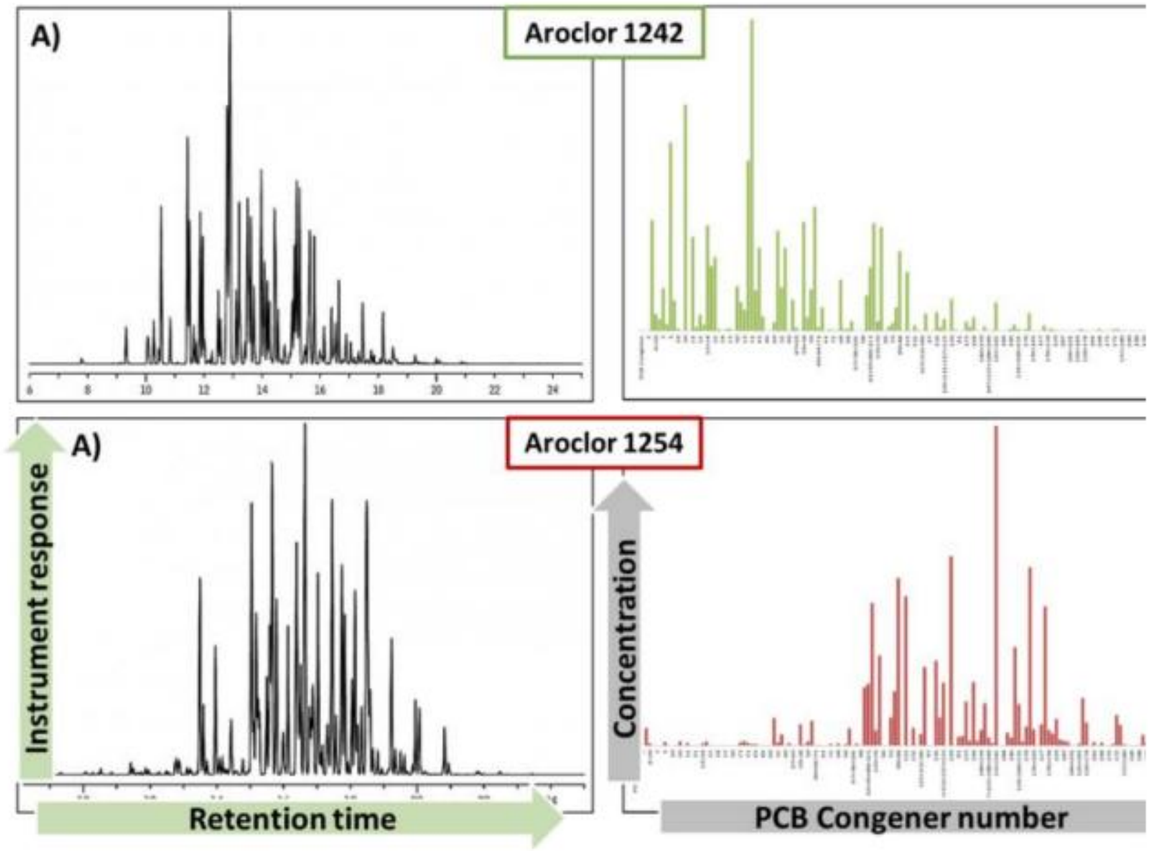
PCB ANALYSIS

GASCHROMATOGRAPH

MOST RECOMMENDED STANDARDS FOR EUROPE

IEC 61619: developed in Europe, more accurate, large number of labs able to run

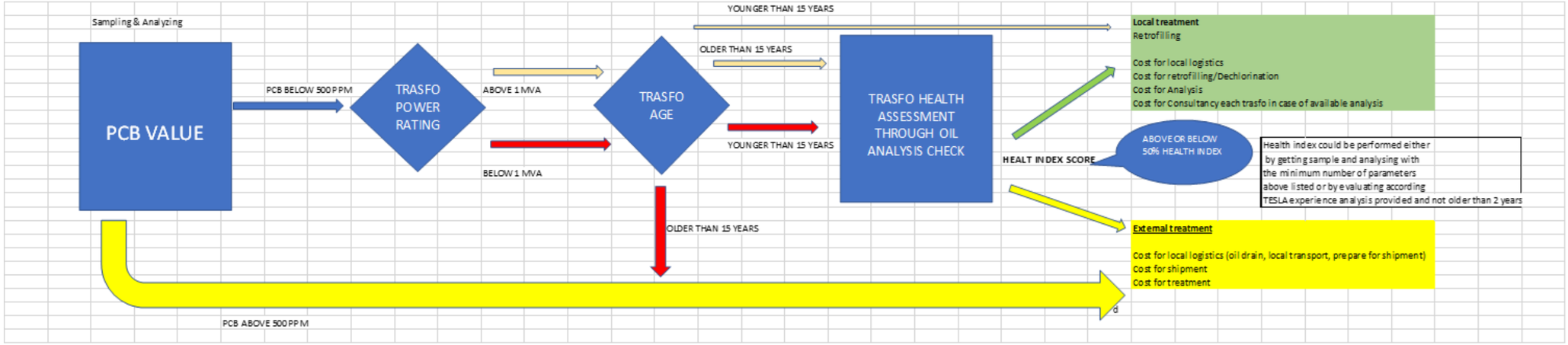
EN 12766 part 1,2,3: very useful to detect PCBT =Ugilec (impact on France origin products)



SOURCE https://pcb.unitar.org/pcb-elearn-pcb-laboratory-analysis/:

DATA ELABORATION

Data Lead to Decision



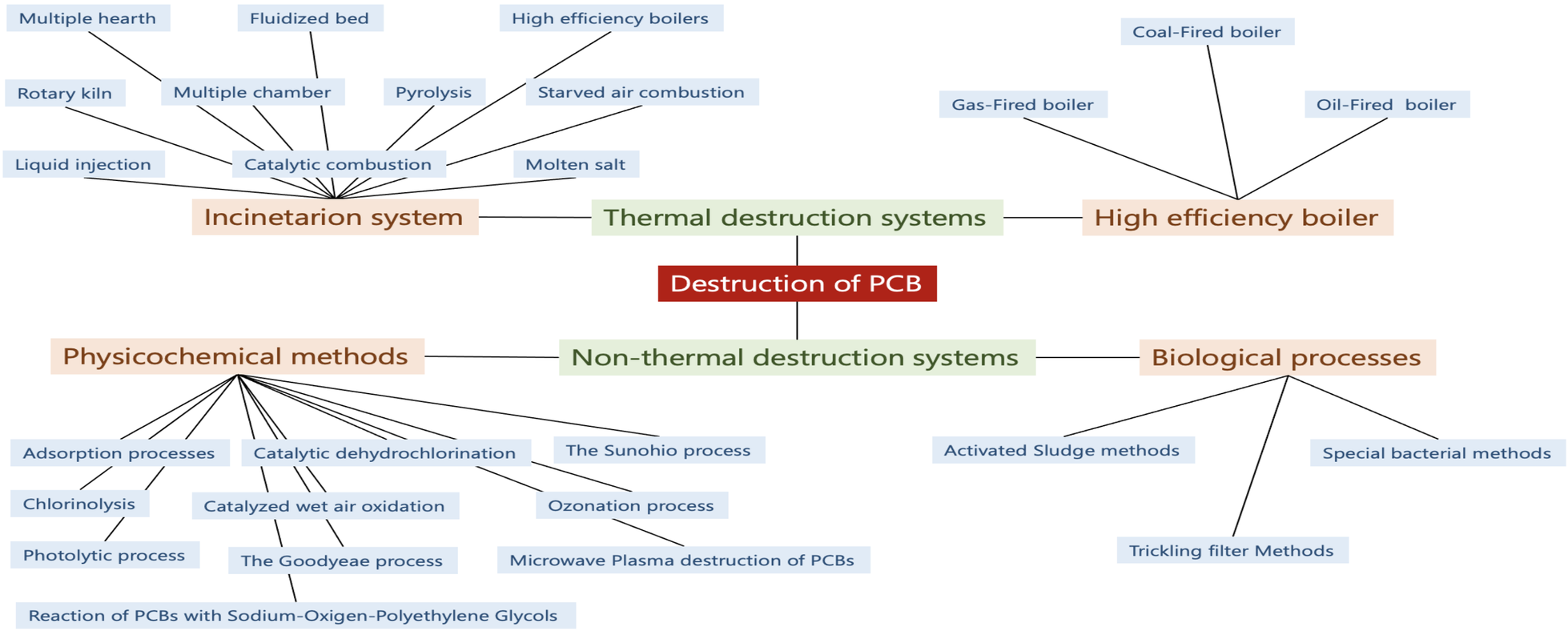
Some AI agents developed by third party could now help to quick implement data and identify contamination patterns

PCB Elimination[1]

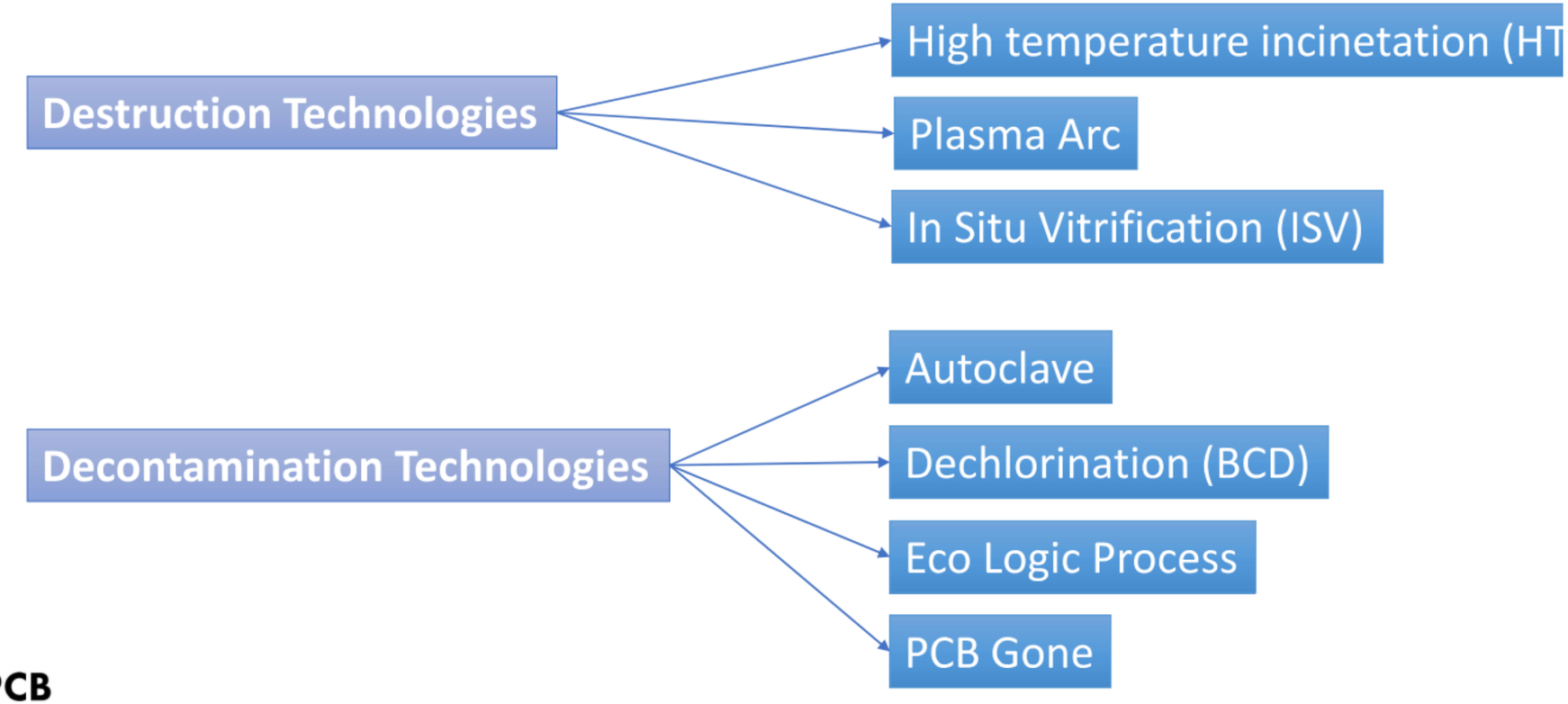
PCB Elimination Processes

- 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)



AVAILABLE TECHNOLOGIES



HIGH TEMPERATURE THERMAL DESTRUCTION LAY OUT

Thermal treatment hazardous and industrial waste

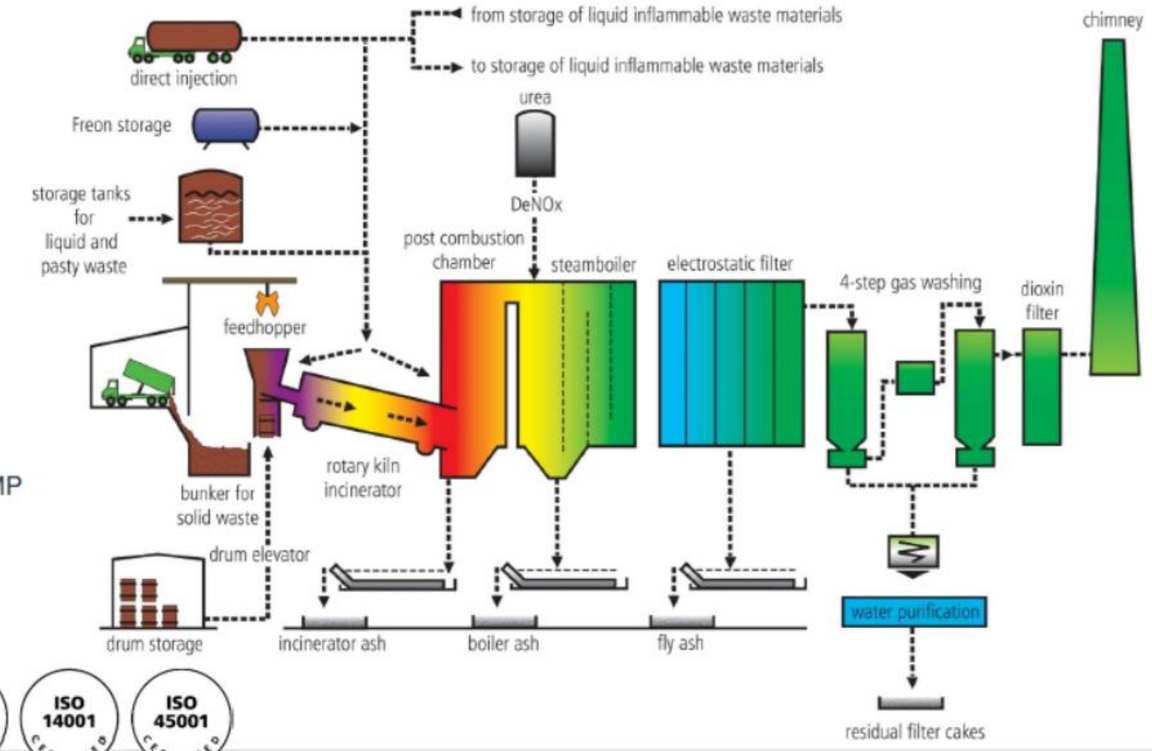
- Incinerator lines: : 3
- Extensive flue gas washing
- Physical condition: : liquid, pasty & solid
- Throughput : 2 x 7,8 T/H
- Incineration temp. : 1100 °C
- Calorific value : 14,000 kJ/kg
- Duration: : 25-35 min.

- Gas washing in electronic filter, 4-multiple wet gas washing, dioxin filter
- Residual waste → Landfill cat. 1

Heat supply to neighbouring company + IndaMP

ISO 9001 CERTIFIED ISO 14001 CERTIFIED ISO 45001 CERTIFIED

Process scheme



SOURCE:SARPI PCB

FEATURES

Targeting:

- liquids even high PCB grade
- capacitors

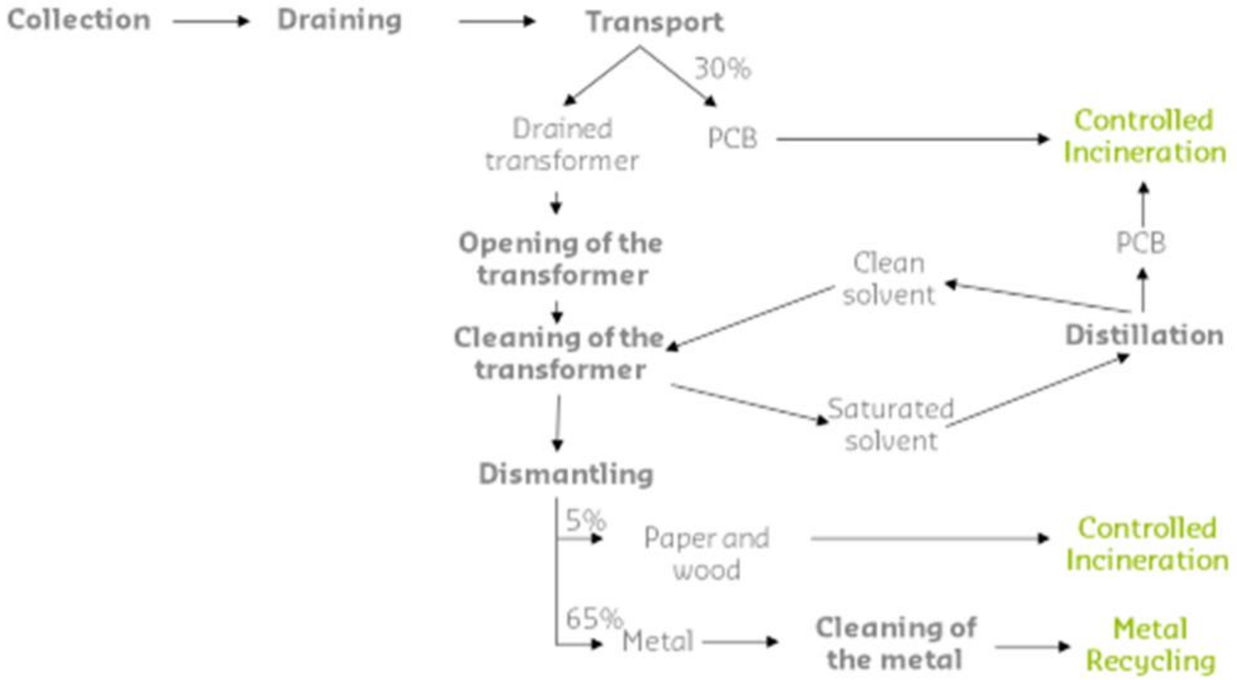
Locations:

at least 8-9 operational plants across Europe

PROS: logistics, price stability,
CONS: lack of flexibility, impacting costs on packaging for small amount delivered

AUTOCLAVE PROCESS

- 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%



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Control of documents → TRACEABILITY

Weighting (< 6 tons : 2 kg)

Registration

- Unique N°/transfo
- Date
- Producer
- Reference producer
- Power (kVA)
- Weight
- Production year
- Transporter

Separation of cores and casings

Cores in Autoclaves

PROS : metal recycling , stable pricing policies, logistics

CONS: size limitations (10 tons), porous materials to be destroyed

Shredding and full copper recycling

Dechlorination

Chemical Dechlorination is based on reactions with either an organically bound alkali met an alkali metal oxide or hydroxide.

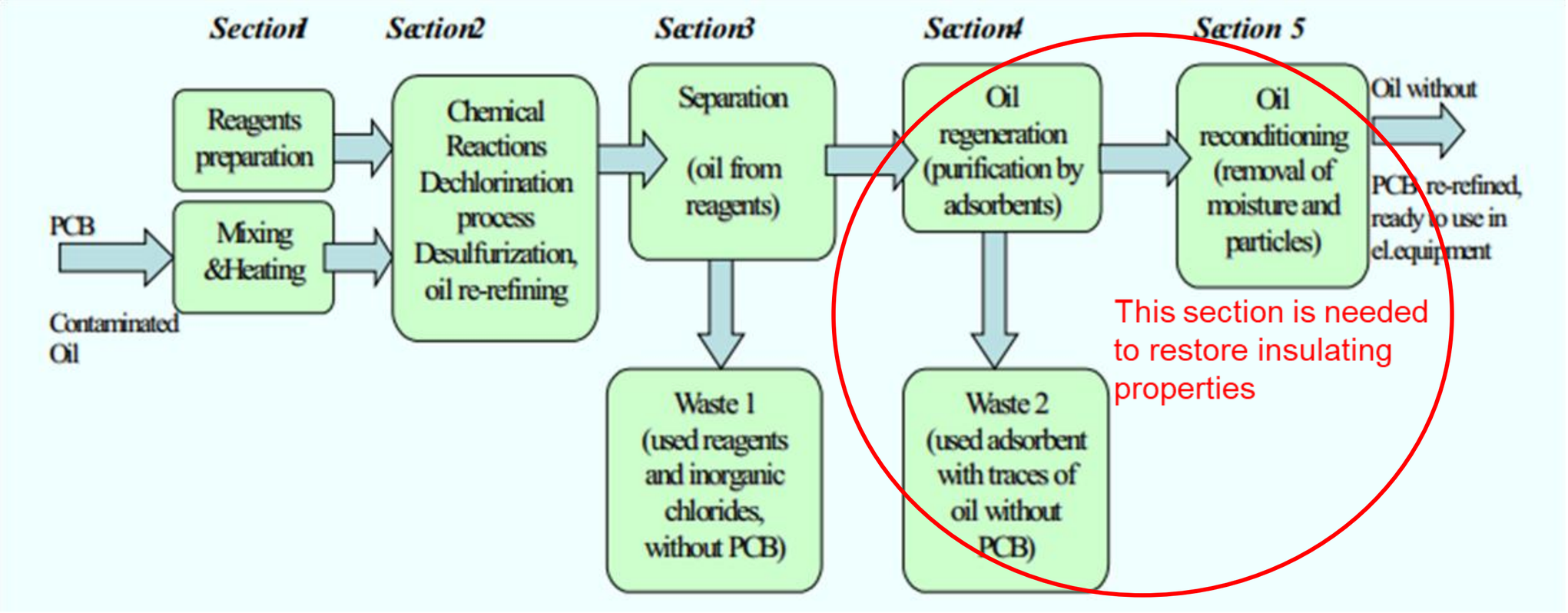
- The chlorine content is converted to inorganic salts, which can be removed from the organic fraction by filtration.
- Can treat wastes up to 10 % PCB (in 2 h)
- The key to the process is the hydrogen donor with anoxidation potential low enough to produce nucleophilic hydrogen in the presence of base NaOH at low temperatures.

Overview of PCB disposal technologies - Carlo Lupi – UNIDO cons

SOURCE OF ALKALI /HYDROXIDE:

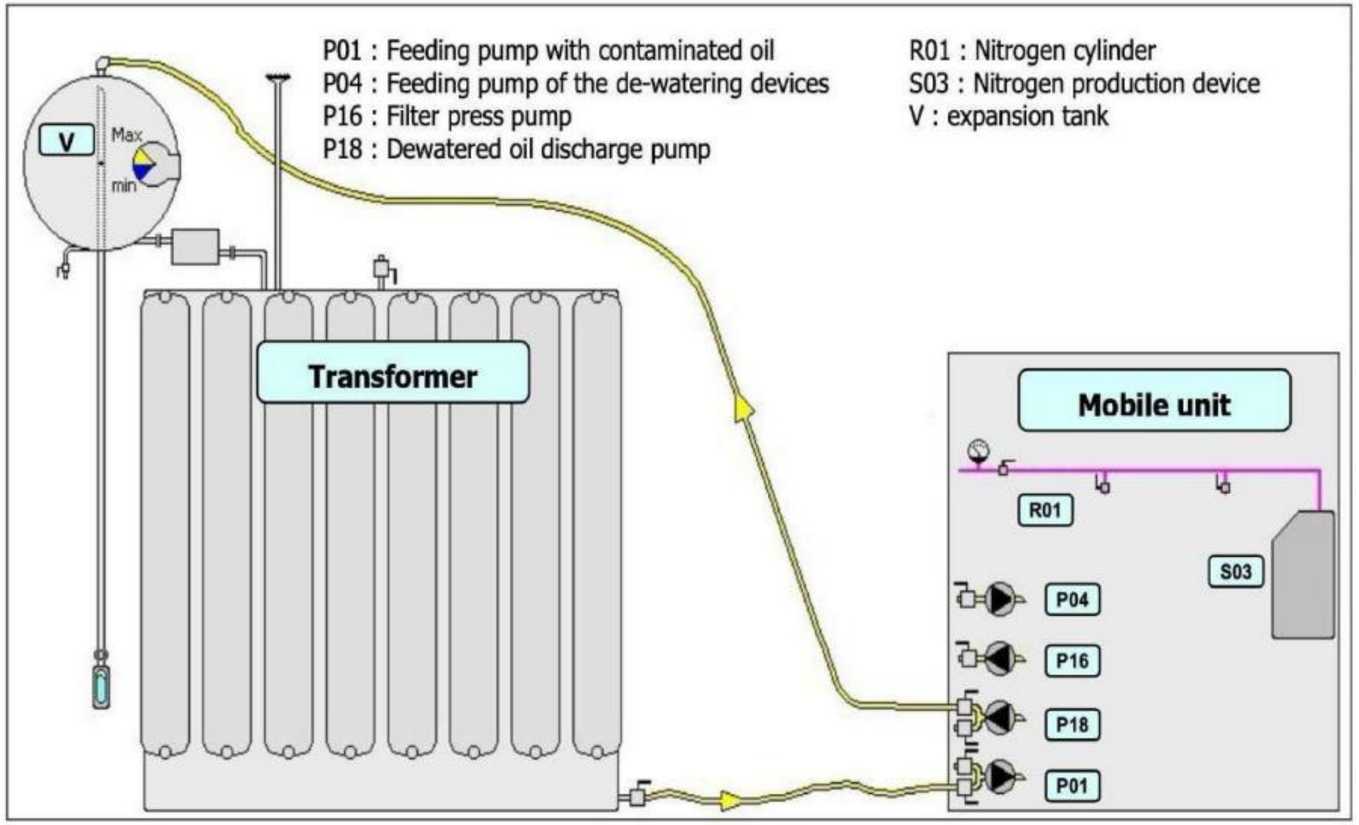
- Metallic Na/Li
- Disperse Ca in glicerine
- Kpeg, PPG

Dechlorination typical process



Source: Nikola Tesla Institute of Engineering

Example of Canadian Mobile Unit with direct operation mode with transformer



PCB PLATFORM

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PROS

1) mobile/stationary
2) big size Transfo
3) in life assets
4) Online option
5) low cost to purchase Tech
6) Oil recovered as resource

CONS

1) Treatment duration
2) daily productivity
3) Questionable >500 mg/kg PCB
4) Porous parts?
5) Limited efficiency on some PCTs/PCBTs
6) Reagents wasted
7) Medium risk of fire for Na/K/Li
8) Some knowledge of Elechtromecanics

Is the process by which pure PCBs or oil polluted PCBs is replaced with a not contaminated transformer oil. Is normally applied to “in life” transfo.

10-20% of initial PCB contamination remains in the porous parts so for value above 500 mg/kg several changes are needed

20-30% of oil weight is to be added for overwashing the internal parts: waste production 30% higher than oil weight

Source: SARPI PCB

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RETROFILLING

REMARKS:

- IEC/CENELEC suggest to wait 3 months before oil check to confirm warranty < 50 mg/kg
- The bigger the trasfo is the worse the results are as it implies some knowledge of elechtromecanical practices

- Not reliable for transformers > 500 mg/kg PCB.
- The core is containing porous parts like wood and paper. It is proven, these parts are not cleaned <50 mg/kg with a simple rinse/wash!!

Experimental PCB results (in ppm)				
		result after chemical clreaning		
Oil		Metal	wood	paper
271		<1	256	156
346		<1	101	96
		result after chemical clreaning		
214		Wood surface		107
		Wood core		115

NON EXAUSTIVE LIST OF **HIGH TEMPERATURES DESTRUCTION PCB PLANTS** IN EUROPE

COUNTRY	REMARKS
FRANCE	
ITALY	Only liquids < 500 mg/kg
SPAIN	Limitation in materials
UK	Limitation in materials/concentrations
BELGIUM	
THE NETHERLANDS	Limitation in materials/concentrations
GERMANY	Limitation in materials/concentrations
SWITZERLAND	
POLAND	Limitation in materials/concentrations
ROMANIA	Limitation in materials/concentrations
SWEDEN	

Source: own elaboration

NON EXAUSTIVE LIST OF **PCB DECONTAMINATION AUTOCLAVE-BASED STATIONARY FACILITIES** IN EUROPE

COUNTRY	REMARK
FRANCE	
ITALY	Foreign Waste Acceptance Limitations
SPAIN	
UK	Small capability
BELGIUM	
THE NETHERLANDS	
ROMANIA	No Foreign Waste Accepted
The total capability is estimated up to 10.000 tons/year (potential) that is sufficient for current European needs and allowing import from other continents	

Source: own elaboration

NON EXAUSTIVE LIST OF **PCB DECONTAMINATION DECHLORINATION-BASED STATIONARY FACILITIES** IN EUROPE

COUNTRY	REMARK
FRANCE	Not operational
ITALY	Not operational
SPAIN	
UK	Only for very low contaminated oil
NORTH MACEDONIA	
TURKEY	
AZERBAIJAN	
Plants in Italy, North Macedonia, UK, Turkey use PPG, PPEG tech Plants in France, Spain, Azerbaijan Na based tech	

Source: own elaboration

NON EXAUSTIVE LIST OF **PCB DECONTAMINATION DECHLORINATION-BASED MOBILE PLANTS MANUFACTURERS** IN EUROPE

COUNTRY	REMARK
ITALY	Na based or K-Peg/PPG
GERMANY	Na based
SERBIA	K-Peg/PPG
UKRAINE	Na Based
RUSSIA	Unknown
Only one manufacturer in Italy and one in Serbia have «ready to deploy» plants both with K-Peg/PPG **Only one manufacturer in Italy has know how for «online» decontamination**	

Source: own elaboration

FROM DATA TO DECISION: a way to manage assets

END OF LIFE HIGH/LOW CONTAMINATED DISTRIBUTION TRASFO

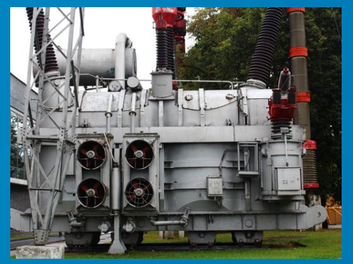
Disposal and metal recycling by stationary Autoclave/Dichlorination

IN SERVICE HIGH CONTAMINATED POWER/ DISTRIBUTION TRANSFO

After tech/economical evaluation:

1) Onsite closed loop/batch dechlorination
2) Immediate end of life

IN SERVICE LOW CONTAMINATED POWER/ DISTRIBUTION TRASFO



1) Onsite closed loop/batch dechlorination
2) Retrofilling

CAPACITORS

THERMAL HIGH TEMPERATURE DESTRUCTION

STATE OF THE ART OF PCB DECONTAMINATION PLANS IMPLEMENTATION IN EUROPE

- INVENTORIES

Done in all countries at different stages

Larger contaminated fleets have been found in western Europe (France, Italy)

Eastern Europe contamination seems limited (focus on railways for capacitors)

Very high level in general of PCB analysis skills

- ELIMINATION

West Europe has finalized achievement at different stages but in general satisfactory with exception for UK where about some thousands of assets are still to be handled

Eastern Europe has limited plant capabilities but could profit of westerners' plants availabilities

- IMPROVEMENT AREAS

Transboundary transportations improvements: fences in some Eastern countries and Italy

Limited availability in Eastern Europe of local partners for logistics and PCB waste packaging

Source: own elaboration

REFERENCES

Following websites could be a source of insights

UNITAR PCB E-LEARN TOOL: https://pcb.unitar.org/pcb-elearn/

STOCKHOLM CONVENTION Guidance: technical guidances folder

WikiTransfo - Sea Marconi: a dedicated transformer & PCB Wiki