

“Oil & PCBs/DBDS Free” Program:

BAT/BEP - LCM (Life Cycle Management) for Inventory, Control, Management, Decontamination of Electrical Transformer PCBs/DBDS contaminated (On Site & On Load)



Vander Tumiatti

- President and Founder of Sea Marconi Technologies, Turin (Italy) since 1968
- Ass. Secretary IEC TC 10 (International Electrotechnical Commission) Geneve-CH
- IEC «1906 Award» - 2009
- Expert PEN - UNEP (POPs-PCBs Elimination Network- United Nations Environment Programme) Geneve - CH



Sea Marconi - Key Information



- **Foundation:** 1968, by Vander Tumiatti
- **Mission:** Protection of company assets and environmental resources
- **Activities:** Research, Technologies and Services for Energy & Environment
- **Clients:** > 3,000 users in the energy, industry and service sectors, worldwide
- **Human resources:** about 100 employees
- **Quality & accreditation:** ISO 9001-2008 Globe, ACCREDIA
- **Patents:** over 40 in EEC, USA, etc.
- **Expertise:** members in WGs (IEC, CEN, CIGRE)

Headquarters (North Italy)

Where we are



Sea Marconi - Technical Capabilities

Power transformers treated per year (2014)	596
PCBs Dehalogenation (CDP Process®)	80
Depolarisation and Reclaim	92
Reconditioning	415
Oil mass treated per year (2014)	5.971 ton
PCBs Dehalogenation (CDP Process®)	980 ton
Reclaim and depolarisation	1.126 ton
Reconditioning	2.469 ton
Number of decontamination units (DMU by Sea Marconi)	25
Oil samples analysed per Year (2014)	14.800
Transformers analysed per Year (2014)	9.500
Oil test performed per Year (2014)	75.000
Transformers database	70.000
Diagnostics database	200.000

Focus on the Transformer



Scenario

Protection of Resources Assets & Environment

Failure



Explosion



Fire



Damages

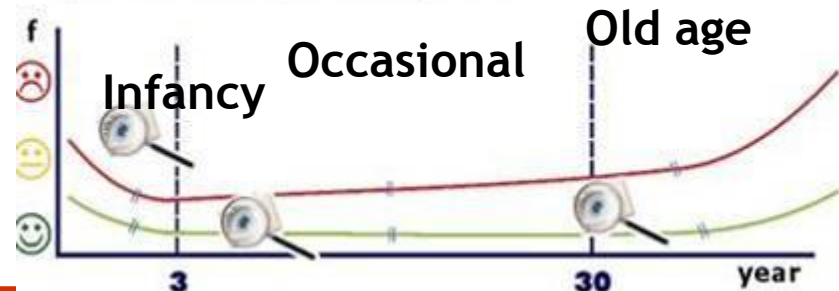


- Direct: Assets & Personal
- Indirect: Production
- Environment: soil, water, air

Black-Out

► **FAILURE RATE:** ~ 3%/year (typical for 30 years old)

► **LIFE:** average 30-40 years



PCBs: Regulation & Standards

EUROPEAN DIRECTIVE n. 59/96 of 16.09.1996

ARTICLE 2

(a) PCBs means

- POLYCHLORINATED BIPHENYLS
- POLYCHLORINATED TERPHENYLS (PCTs)
- MONOMETIL-TETRACHLORO DIPHENIL METHANE, (PCBT)
- ANY MIXTURE CONTAINING ANY OF THE ABOVE MENTIONED SUBSTANCES IN A TOTAL OF MORE THAN **0,005%** BY WEIGHT

ARTICLE 3

“.....DECONTAMINATION and or DISPOSAL shall be effected at the last by the end of
“2010”

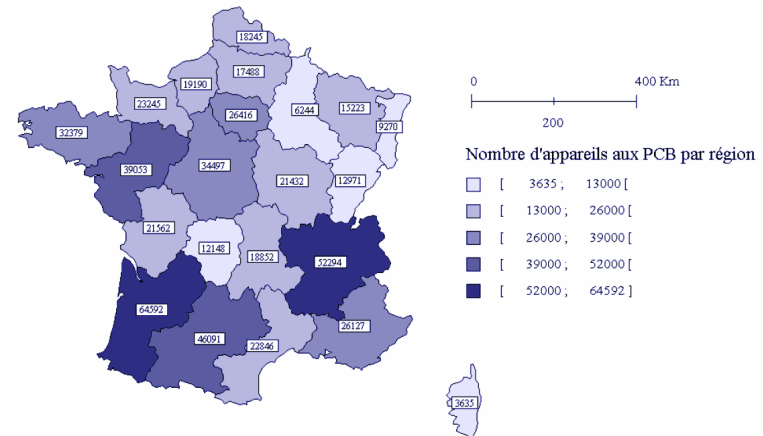
ARTICLE 4 INVENTORY

“....within 3 years of the adoption of this Directive”

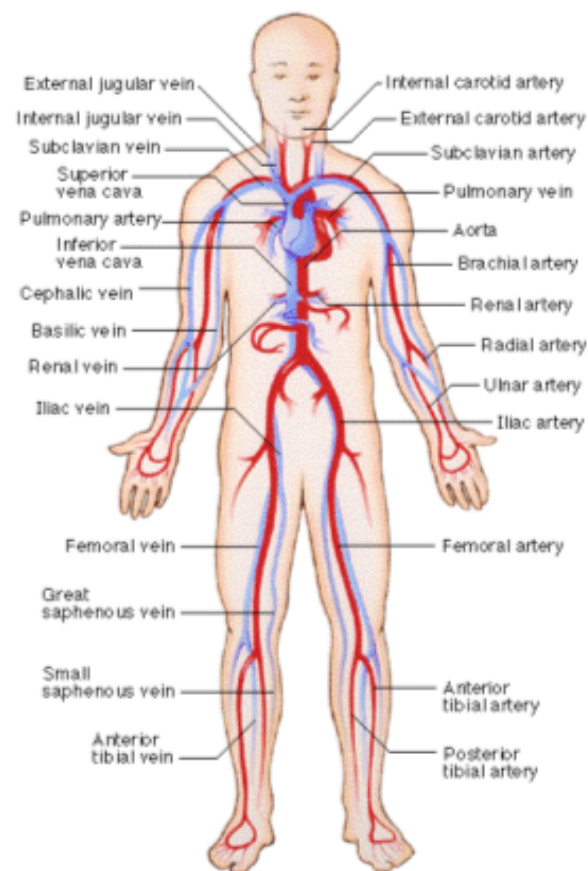
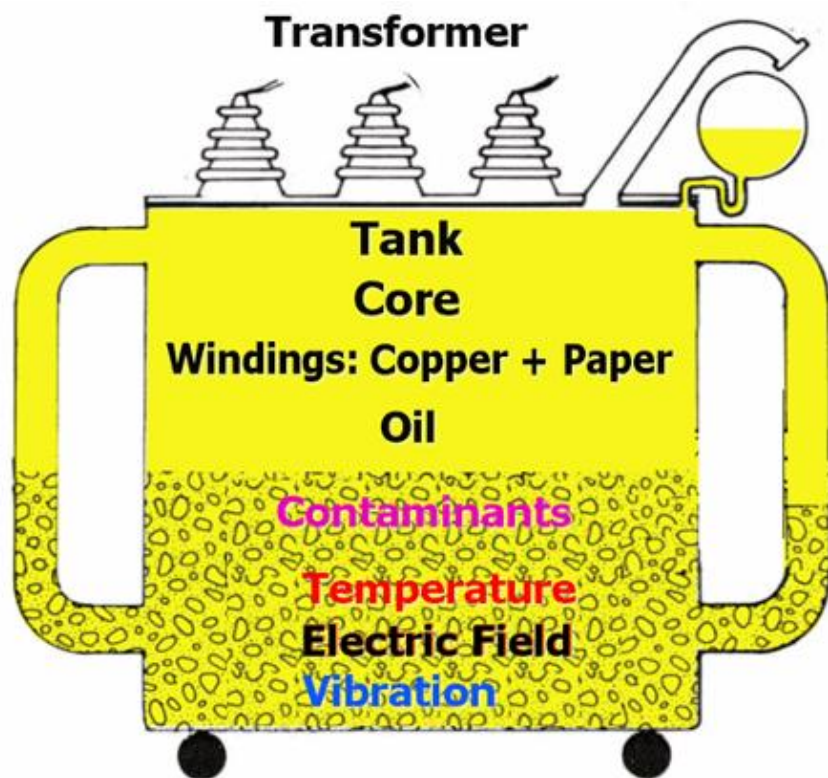
PCBs INVENTORY IN FRANCE

(30 June 2002)

545,610 units



INSULATING FLUID like “*HUMAN BLOOD*”



Sampling for Diagnostic Tests



Transformer oil



“Human blood”

SEA MARCONI: Life Cycle Management (LCM) approach

Sea Marconi Laboratory

Advanced analysis methods
Quality certification:
ISO 9001; ISO 17025-2000

Our laboratory analysis is among the best in the world:

- for the range of tests performed
- for the technologically advanced instrumentation
- for the methodologies used



Lab. n° 0899

Membro degli Accordi di
Mutuo Riconoscimento EA,
IAF e ILAC

Signatory of EA, IAF and
ILAC Mutual Recognition
Agreements

Accredited tests:

- PCBs, PCT, PCBsT, (IEC 61619:1997-04; EN 12766 -3:2004)
- Dissolved water (IEC 60814:1997-08)
- Furfural and derivative compounds (IEC 61198:1993-09;)
- Dissolved gases in oil (IEC 60567:2005-06)

Accreditation internationally accepted

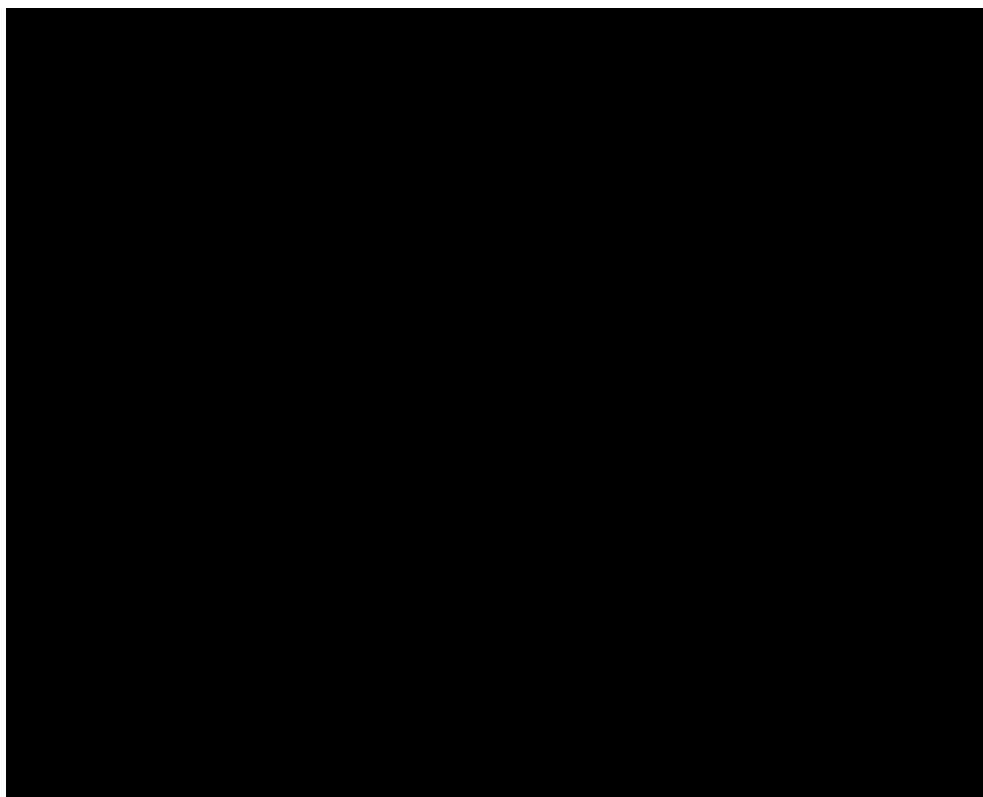
Diagnosis for identification of functional and environmental criticalities (According to IEC 61619, EN 12766)

Trend analysis

[illegible]

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Oil & Transformer decontamination



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**Decontamination Mobile Unit (DMU)
for oil & transfo, On site & On load**



“Human blood dialysis”

SEA MARCONI solution: PCBs dehalogenation

CDP Process®

Dehalogenation of PCBs and Environmental protection



Patent:

EEC 0675 748

USA 5.663.479

**The closed-loop,
continuous-mode,
risk-free
decontamination of
PCBs**

CDP Process® is the exclusive and safe technology for the Dehalogenation/Detoxification of PCBs in insulating oils with the functional recovery and “PCBs-FREE” re-classification of transformers

SEA MARCONI solution: PCBs dehalogenation

CDP Process®

Patents CEE n.0675 748 - USA n. 5.663.479

- 1982** First patent
- 1983** Successful application for the complete dehalogenation of the 2,3,7,8 TCDD, Dioxin of the “Seveso Case” in Italy
- 1985** Industrial application on power transformers oil in non-continuous mode (batch process)
- 1992** Development of continuous process (Close cycle)
- 2003** On load application on high voltage power transformers
- 2007** from the **BAT** Reference Italian Ministry of the Environment as **Best Available Technique** for PCBs decontamination of electrical equipment in service (Official Gazette n.133)

Dehalogenation & Detoxification of PCBs

Chemical process capable to eliminate or reduce PCBs contamination from insulating oils.

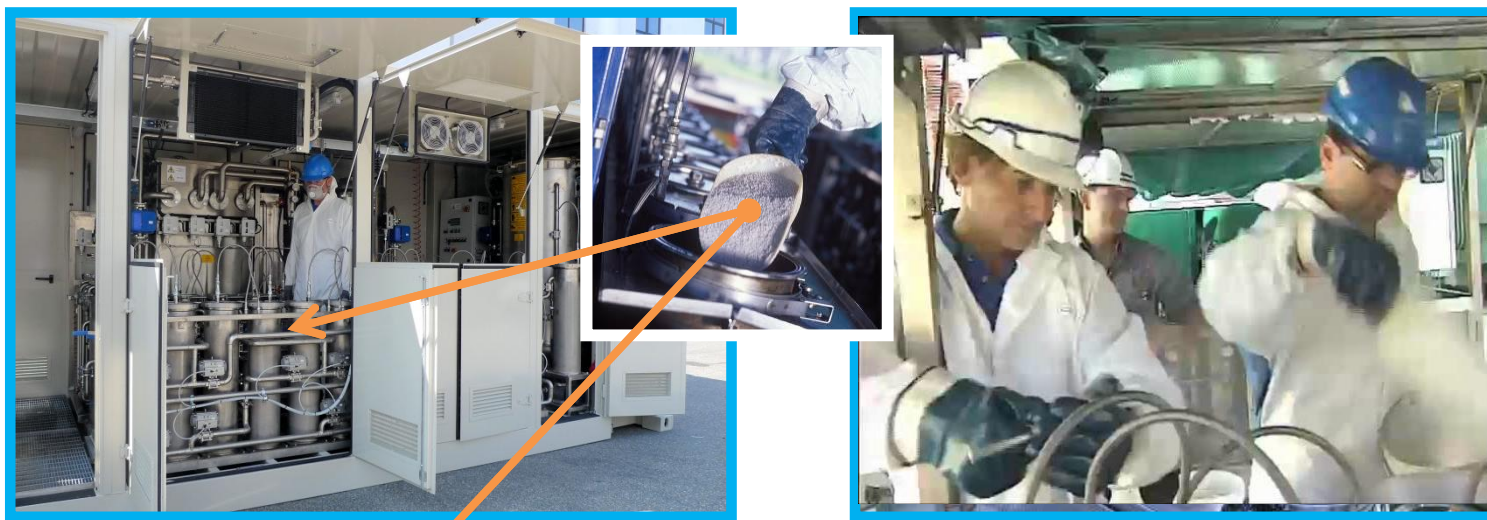
Several type of process are available, the best compromise between efficiency and safety conditions is the dehalogenation in continuous mode by closed circuit process (CDP Process®) by Sea Marconi.

The process uses a **solid reagent** consisting of a high molecular weight glycol mixture, a base and a radical promoter for the **chemical conversion organic chlorine to inert salts.**

Typically it includes: heating to 90-100 °C, filtration, vacuum treatment, chemical reaction and percolation under pressure through suitable materials.

Dehalogenation Sea Marconi - How does it work?

The dehalogenation (CDP Process®) is performed using Decontamination Mobile Units (DMU) by Sea Marconi + patented solid reagent (S/CDP®). The reaction takes while the oil is circulated through a percolation columns, filled with a solid reagent containing glycols (PEG, PPG) and strong basis on a solid matrix.



Without S/CDP® reagent, the dehalogenation would not provide the same results against PCB!!!

PCBs dehalogenation with Mobile Unit (DMU)

The oil flows through the column filled with special **solid reagent** (patented by Sea Marconi).

The patented reagent is composed by a suitable mixture of inert aluminosilicate support and active chemical reagents.

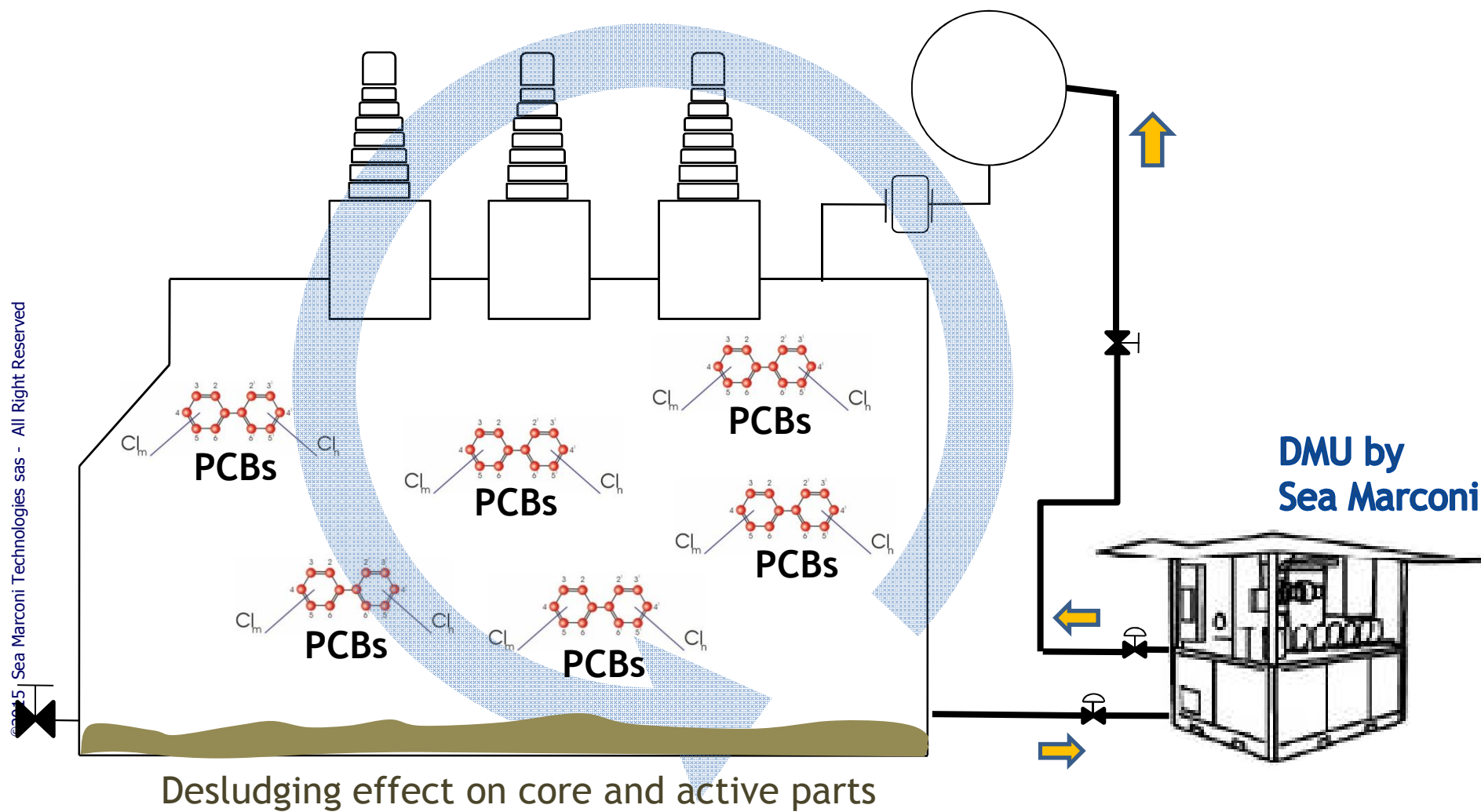


The S/CDP[®] reagent decontaminates the oil with PCBs (and other chemical physical contaminants) converting the PCBs into biphenyl and an inert and harmless inorganic salt.



SEA MARCONI solution: PCBs dehalogenation

CDP Process® - Schema of PCBs dehalogenation

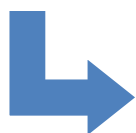


PCBs decontamination Techniques comparison

CDP Process®: Best Available Technique (BAT)

Italian Ministry of the Environment, the Territory and the Seas

Decree 29/01/2007 - Published on the Official Gazette n.133:



Guidelines for the identification and utilization of the Best Available Techniques on Treatment of PCBs, apparatuses and wastes containing PCBs and stocking systems

Table E3 - Decisional matrix for the various available techniques

METHODS	Functional Safety	Environmental safety	Operator Safety	Eco-balance and Emissions	Global Cost/Benefit Ratio
Retrofilling	***	**	***	*	**
Sodium, Lithium and Derivates	*	*	*	**	*
KPEG	**	***	***	**	**
Continuous Closed-Loop Dehalogenation (CDP Process®)	***	***	***	****	****



**** = OPTIMUM; *** = GOOD; ** = AVERAGE; * = CRITICAL

PCBs decontamination, alternative techniques

Sodium, Litium and derivatives

(Ref IEC 60422, Ed. 4 2012, 12.4.2)

- Alkaline metals sodium, lithium and derivatives
- Oil Temperature > flash point (150-300 °C)
- Risks of explosion and fire with water and air
- Non continuous process



NON CONFORMITY
(EC Directive 96/61/CE)



SEA MARCONI solution: PCBs dehalogenation

CDP Process®: features of the process

(CENELC TR 50503 8.4.2.3; IEC 60422 Ed 3 12.4.4; Cigre Brochure no. 413 10.1.4)

- Exclusive Technology developed by Sea Marconi
- Use of solid reagent for de-chlorination of PCBs
- Low operational pressures and temperatures (< 80 -100°C)

CDP Process® = PCBs dehalogenation + oil regeneration simultaneously = recovery of oil properties and extension of transformer life-time



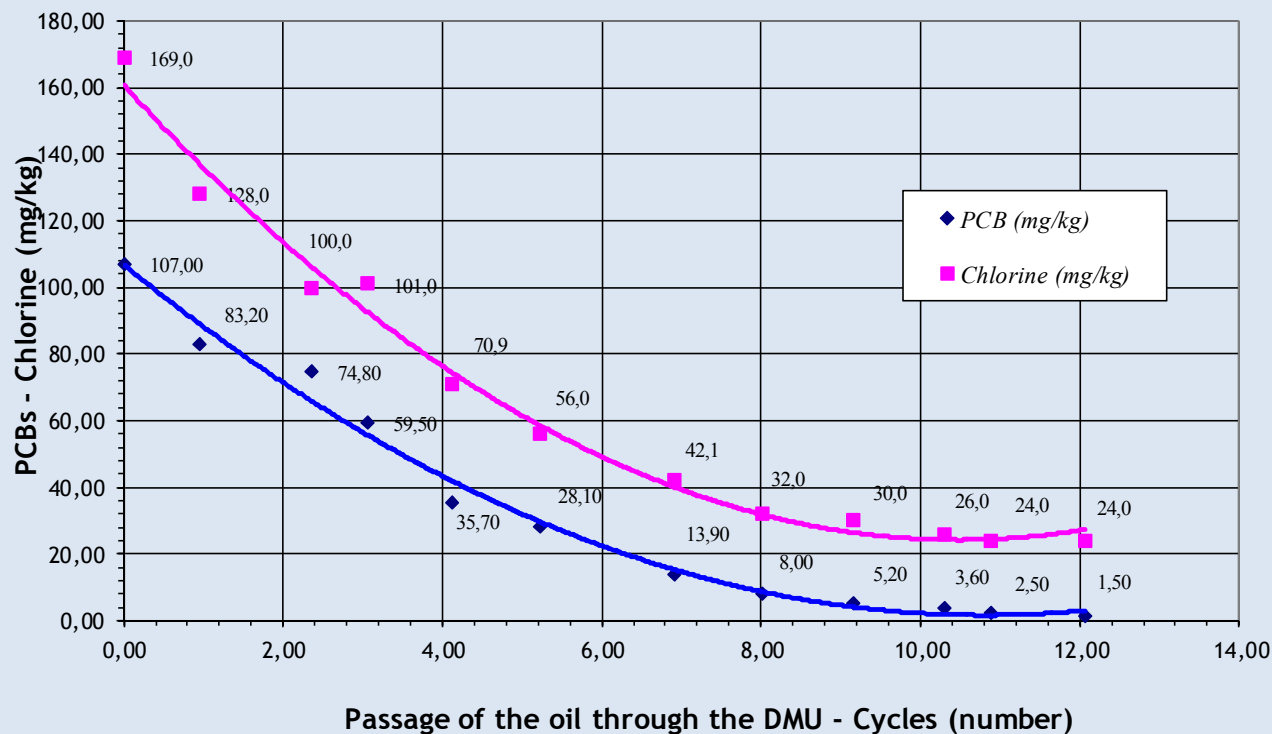
- NO “Oil replacement technology”
- NO PCB Waste
- ON-SITE Process: No need for transportation of “big” transformers
- PCB-decontamination of oil in continuous, closed loop (without draining the transformers)
- Performed with **DMU** (Mobile Decontamination Units) - safety and high automated

Dehalogenation & Detoxification of PCBs

CDP PROCESS® - Continuous Dehalogenation Process

AUTOTRANSFORMER 250 MVA 400 KV

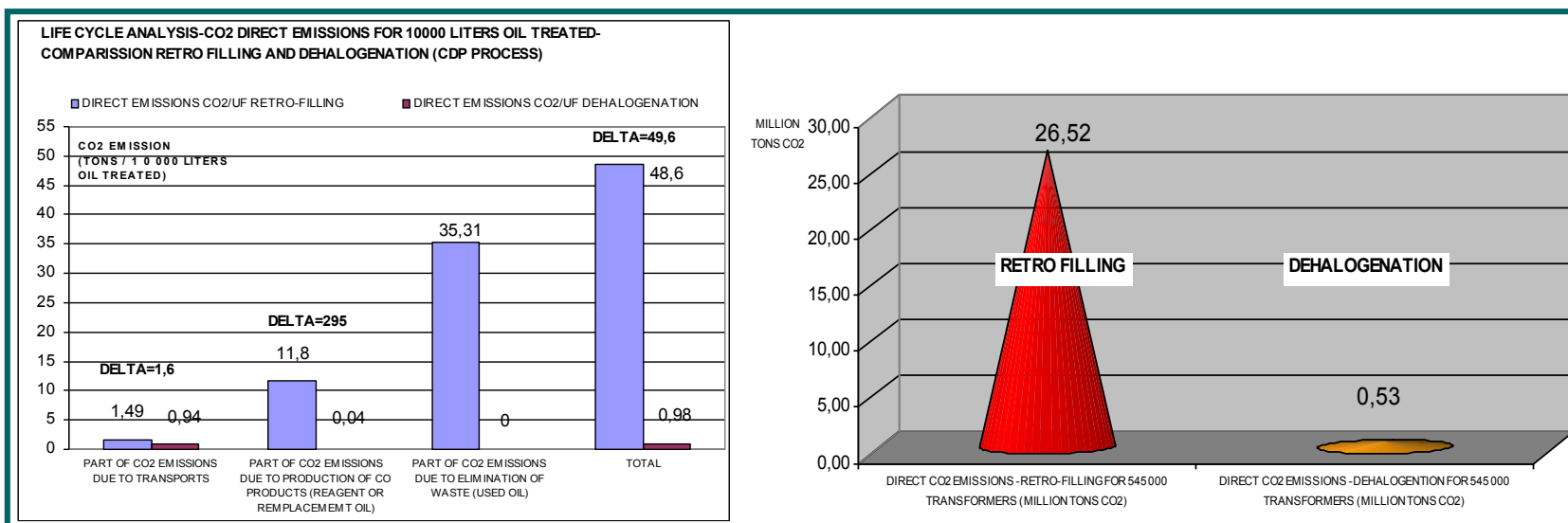
Curve of PCBs / Chlorine concentration as a function of the passage of the oil through the DMU (cycles)



SEA MARCONI solution: PCBs dehalogenation

Environmental Performance of CDP Process®

- Chemical destruction of PCBs (PCB-free waste)
- Top-level countermeasures to avoid PCBs release during process
- Low temperature process and heat-recovery technology
- Avoidance of massive CO₂ emissions in comparison with incineration



LCA and CO₂ emissions: CDP Process® vs Retrofilling

SEA MARCONI solution: PCBs dehalogenation

2 alternative layouts

Mobile units

Continuous mode

Closed circuit

Stationary plant

Batch mode

Open circuit



Without emptying the transformers



PCBs dehalogenation with Mobile Unit (DMU)

Mobile Unit - Continuous Mode

Dehalogenation of PCBs and environmental protection

THE CLOSED-LOOP, CONTINUOUS-MODE, RISK-FREE DECONTAMINATION OF PCBs



CDP Process® is the exclusive and safe technology for the Dehalogenation/Detoxification of **PCBs** in oils with the functional recovery and “**PCB-FREE**” re-classification of transformers

Operational Phases of the treatments

1. DMU installation
2. Transformer-DMU, Hydraulic connection
3. Electrical connection
4. Oil sampling and initial verifications
5. Chemical - physical treatment
6. Process controls during treatment
7. Oil sampling and final verifications
8. Hydraulic and electrical disconnection
9. Level verification and purges
10. DMU removal

PCBs dehalogenation with Mobile Unit (DMU)

DMU installation

Unloading, handling and installation of the units and materials with fork lift truck or crane near the transformers to be decontaminated



PCBs dehalogenation with Mobile Unit (DMU)

DMU installation

This operation can be done with the transformer on-load, ever respecting the safety distances from the on-load live parts



PCBs dehalogenation with Mobile Unit (DMU)

Key Features

- ON-SITE Process:
 - No need for transportation of “big” transformers
 - ON-LOAD Option (transformers in charge)
- PCB-decontamination of oil in continuous and closed loop (without draining the transfo)
- Performed by **DMU** - Mobile Decontamination Units - high automated
- **Oil & Transfo maintenance:**
 - *PCB-decontamination* +
 - *oil regeneration* simultaneously =
recovery of oil properties and extension of transformer life-time



PCBs dehalogenation with Mobile Unit (DMU)

Operational conditions

- Temperature < 100 °C
- Filtration < 1 μ
- Vacuum < 1 mBar
- Flow rate 500 - 2.000 l/h
- Materials: Basic media, clay, Solid reagent



PCBs dehalogenation with Mobile Unit (DMU)

SAFETY FEATURES - Process Monitoring

- The DMU are equipped with process control logical systems (PLC)
- Oil circulation is automatically stopped in case of emergency
- Process control is independent from the physical presence of an operator - the unit operates 24h (GSM Remote Alarm and Monitoring)

The monitoring is extended to all relevant parameters:

- Temperature
- Pressure
- Flow rate
- Oil level in vacuum chamber
- Smoke detector



**SAFETY
MEASURE**

PCBs dehalogenation with Mobile Unit (DMU)

Protection system

The DMU are equipped with an Alarm Transmission Device, connected with mobile or fixed telephone line.

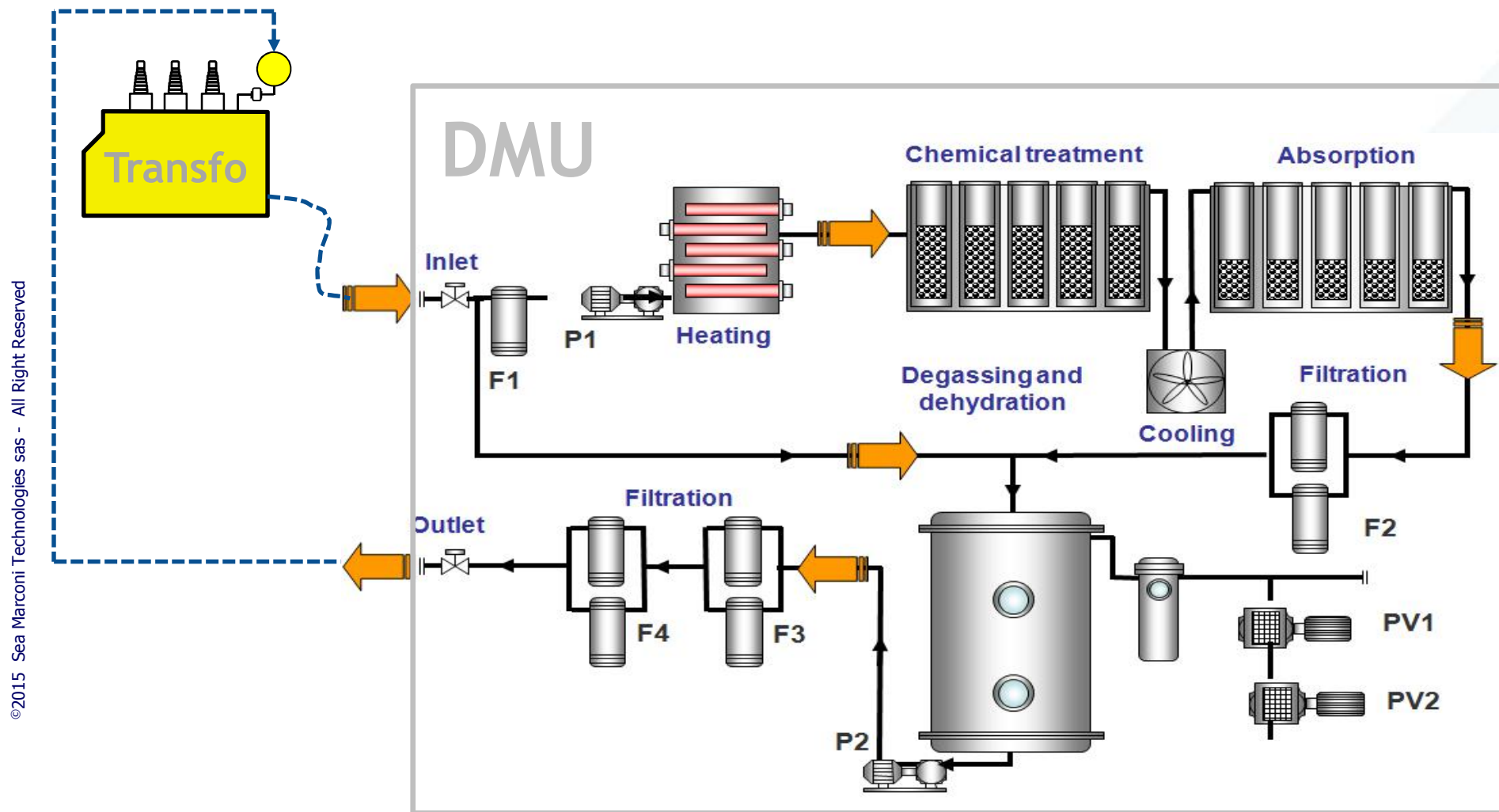
Being the oil circulation stopped by the supervision system, an alarm call is transferred to the operator.

The protection devices of the transformer (Buchholz relay, temperature, ground protection, etc...) shall be interconnected to the supervision system of the unit: being active one of the transformer protection, oil circulation must be immediately stopped.



PCBs dehalogenation with Mobile Unit (DMU)

DMU-Transformer, simplified flow diagram



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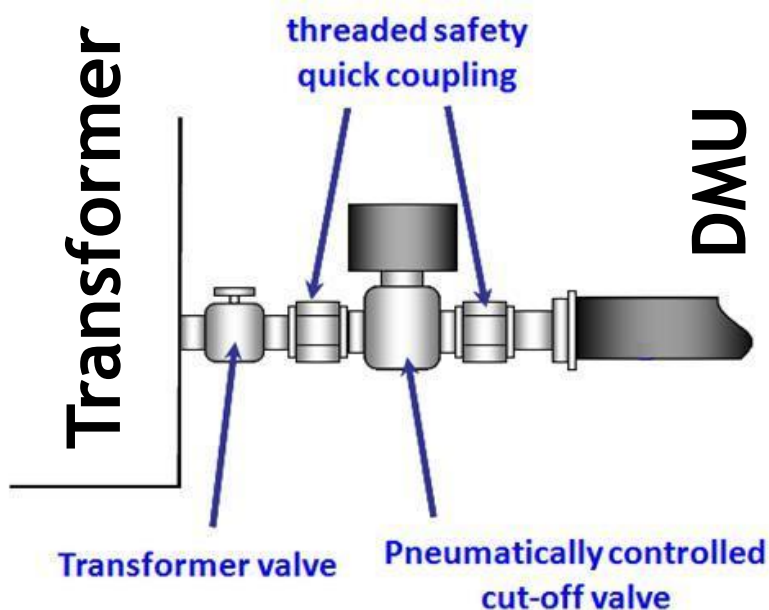


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PCBs dehalogenation with Mobile Unit (DMU)

DMU-Transformer Hydraulic connection for On-Load treatments

The system uses flexible steel hoses and screwed-type coupling, with automatic cut off system in case of disconnection.



The hoses are equipped with Anti-spill connections (conic needle valve)

Pneumatic valves at both ends connected to the logic control system of the DMU

DMU-Transformer Hydraulic connection for On-Load treatments

The connection system of the pipes is suitable to ensure the electric insulation of the treatment system from the tank of the transformer, to prevent any influence on the correct operation of the grounding protection system.



Also, the system provides the elimination of air contained or accidentally entering during filling of the pipes and oil circulation.

PCBs dehalogenation with Mobile Unit (DMU)

On site Experience

Extreme logistics 2009 - France



Extreme logistics 2015 - Italy



DMU by Sea Marconi, studied for any conditions

PCBs dehalogenation with Mobile Unit (DMU)

On site Experience



**H24 operation
2012 - Brazil**



DMU by Sea Marconi, studied for any conditions

PCBs dehalogenation with Mobile Unit (DMU)

On site Experience



Extreme logistics - 9,000 feet altitude
2012 - Atacama desert (Chile)

16/11/2012

DMU by Sea Marconi, studied for any conditions

PCBs dehalogenation with Mobile Unit (DMU)

On site Experience



Very strict environmental and landscape limitations
2013 - Hydroelectric power station in a National Park (Colombia)

DMU by Sea Marconi, studied for any conditions

PCBs dehalogenation with Stationary Plant (batch)

Stationary Plant - Batch Mode

Dehalogenation of PCBs and environmental protection



Patent:
EEC 0675 748
USA 5.663.479

the batch
discontinuous-
mode, risk-free
stationary plant
for
decontamination
of PCBs

PCBs dehalogenation with Stationary Plant (batch)

Batch technology - Key Features

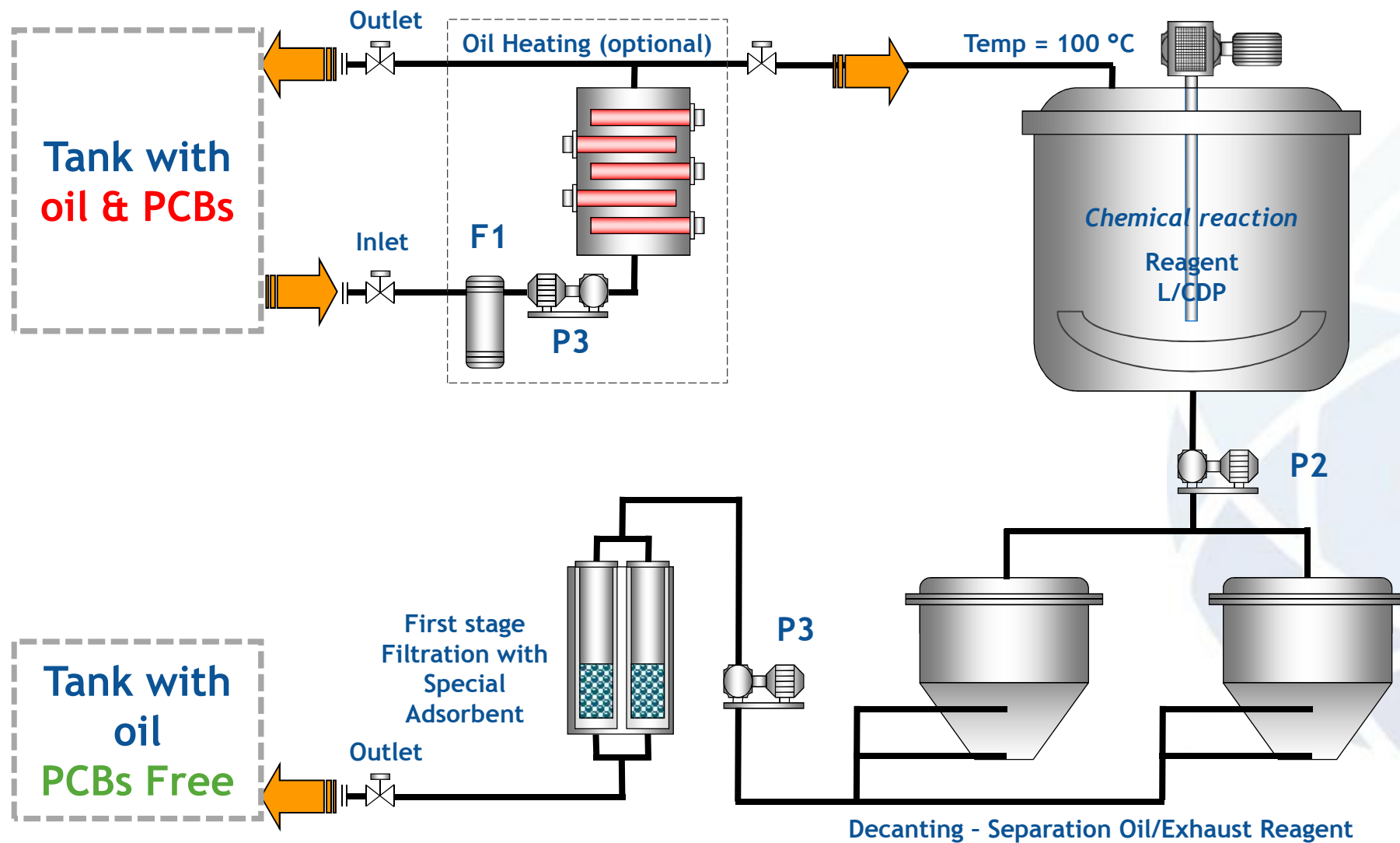
- Suited for rapid PCB-Decontamination of large quantities of insulating fluids
- Solution for “small” transformers collected at storage site:
 - For transformers to be reused: additional compact module for oil treatment (degassing) needed
 - For transformers to be scrapped: decontamination of oil and active parts for PCB-free recycling process
- Dehalogenation takes place in a heated and stirred reactor

- Initial PCBs concentration: up to 50.000 mg/Kg
- Capacity: 6.000÷10.000 l/day



PCBs dehalogenation with Stationary Plant (batch)

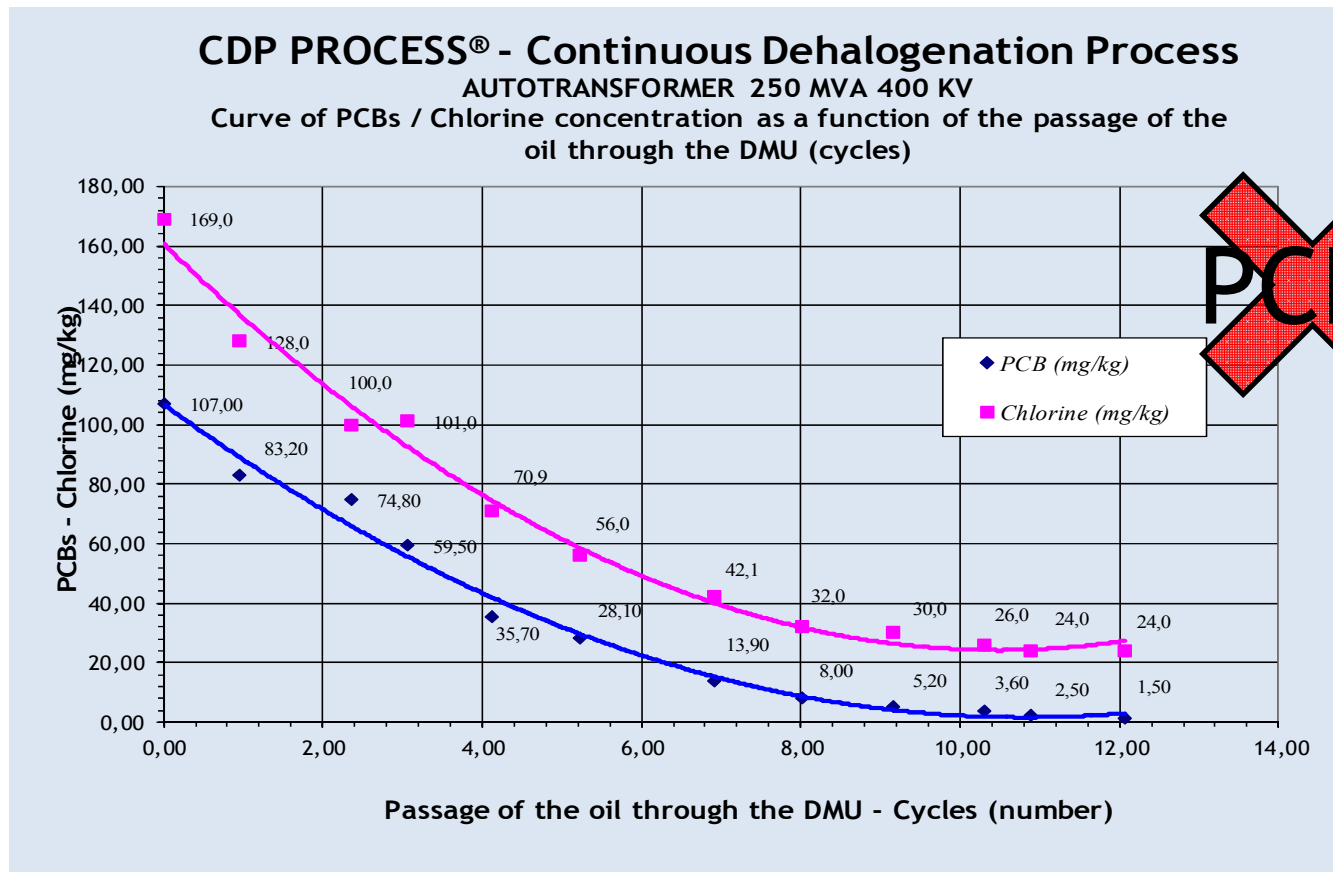
Batch technology schema



Performance of PCBs dehalogenation

Performances of PCBS dehalogenation treatment

Chemical Dehalogenation ensures the effective elimination of PCBs from the oil:



Integrated treatments of Oil & Transformers

1 DMU, 1 Treatment = many solutions

(not only PCBs dehalogenation)

Main function	Physical decontamination	Selective depolarisation	CDP PROCESS® Dehalogenation of PCBs
Recovery of dielectric properties	✓	✓	✓
Recovery of the chemical properties of the oil (acidity, delta tg, colour)		✓	✓
Elimination of sulfur corrosive contaminants, DBDS		✓	✓
Elimination of dissolved organo-metallic contaminants		✓	✓
Dehalogenation/Detoxification of PCBs/PCTs/PCBTs, POPs compounds etc.			✓

Integrated treatments of Oil & Transformers

1 DMU, 1 Treatment = many solutions

- **Physical Decontamination**

- Moisture, gases and particles removal
- restore dielectric properties of the oil

- **Selective Depolarization**

- corrosive sulfur compounds (DBDS and others) elimination
- polar inorganic compounds (metals) removal
- soluble and insoluble oxidation compounds (acids) elimination
- insoluble deposition and sludge removal

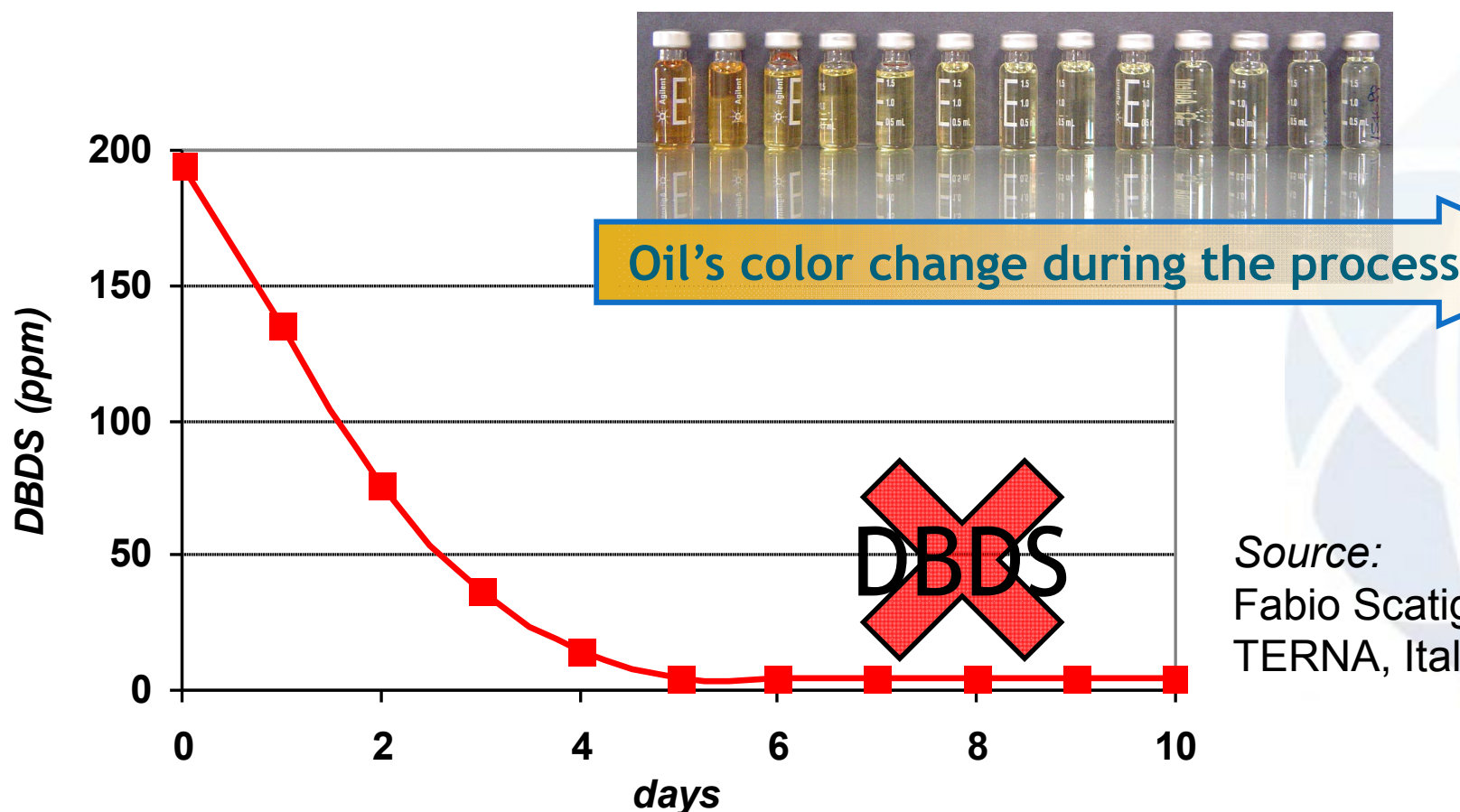
- **CDP Process® Dehalogenation /Detoxification of PCBs**

- halogenated compounds (PCBs and others) elimination

Performance of Corrosive Sulfur decontamination

Performances of integrated treatments

For example the Selective Depolarization treatment ensures the effective removal of **DBDS** from the oil:



Source:
Fabio Scatiggio
TERNI, Italy

Advantages of Sea Marconi integrated treatments

“SM Integrated Treatments” vs “Replacement of Oil”

Key Factors	Sea Marconi Closed loop treatment*	Replacement of Oil
On-Load Operation	Yes ✓	✗ No Off-Load for Draining and Refilling
Requirement of Unused Oil	No ✓	✗ Yes 125%/150% of original mass of oil**
Compatibility of Unused Oil vs original	Safety ✓	⚠ Warning base Oil, additives, others**
Recovery: Physical Properties KV, DGA, H ₂ O	Yes ✓	⚠ Warning*** only after reconditioning of Unused Oil in closed loop §11.2.3 (IEC 60422 Ed. 4 2013)
Recovery: Chemical Properties TAN, DF, IFT	Yes ✓	⚠ Warning*** only after reconditioning+ reclamation treatments of Unused oil in closed loop §11.3 (IEC 60422 Ed. 4 2013)
Removal: DBDS & Corrosive Sulfur	Yes ✓	⚠ Warning*** only if initial DBDS is < 80 mg/Kg or reclamation with special adsorbent
Desludging & Dehydration Solid Insulation	Yes ✓	⚠ Warning*** only after reconditioning+ reclamation of Unused oil in closed loop §11.3 (IEC 60422 Ed. 4 2013)
Decontamination: Dissolved Metals	Yes ✓	⚠ Warning*** only after reclamation with special adsorbent if initial value is 8/10 times higher than the target limit
Dehalogenation: PCBs/POPs in Oils	Yes ✓	⚠ Warning*** only if initial PCBs is 8/10 times higher than the target limit
Self-cleaning unit from: DBDS, PCBs/POPs	Yes ✓	✗ No cross contamination***
Cross contamination by DBDS, PCBs/POPs	Safety ✓	⚠ Warning depending upon the used oil impregnated mainly in the solid insulation
Partial Discharges: bubble air & moisture inlet	Safety ✓	⚠ Warning especially for wet insulation
Environmental Risks for Oil handling	Safety ✓	⚠ Warning high logistical impact
Oil & PCBs Waste disposal	No ✓	✗ Yes especially if PCBs is higher than limit

* Integrated treatments with DMU (Decontamination Mobile Unit) using closed loop process patented by Sea Marconi



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Advantages of Sea Marconi integrated treatments

“SM Integrated Treatments” vs “Fuller Earth treatments”

Key Factors	DMU & Integrated Treatments* Sea Marconi Patented	Treatment with typical Fuller Earth	Treatment with typical Fuller Earth and regeneration > 600-700 °C
Recovery: Physical Properties KV, DGA, H ₂ O	✓ Yes	✓ Yes	✓ Yes
Recovery: Chemical Properties TAN, DF, IFT	✓ Yes	✓ Yes	✓ Yes
Removal: DBDS & Corrosive Sulfur	✓ Yes	✗ No	✗ No
Decontamination: Dissolved Metals	✓ Yes	✗ No	✗ No
Dehalogenation: PCBs/POPs in Oils	✓ Yes	✗ No	✗ No
Classification: BAT/BEP - Best Available Techniques/Best Environmental Practices (PCBs/POPs)	✓ Yes	✗ No	✗ No
Self-cleaning unit from: DBDS, PCBs/POPs	✓ Yes	✗ No	✗ No
Cross contamination by DBDS, PCBs/POPs	✓ Safety	⚠ Danger	⚠ Danger
Corrosion by Sulfur Degradation byProducts (SDBP) as H ₂ S, Mercaptans, etc. due to high temperature (> 370 °C – typical 600-700 °C)	✓ Safety	✓ Safety	⚠ Danger
Dioxins Emissions (PCDDs, PCDFs) due to high temperature degradation byproducts from PCBs/POPs and halogenated contaminants in Oils	✓ Safety	✓ Safety	⚠ Danger

*CDP Process® for PCBs/POPs chemical dehalogenation; CHEDCOS for DBDS & Corrosive Sulfur Selective Depolarization



Process monitoring & Safety measures

Sampling

Before performing the process, a representative sample must be taken for a suitable sampling point and the data of the transformer are collected in sampling form.



Sampling regulation reference:

IEC 60475 - Method of sampling liquid dielectrics

IEC 60567 - Guide for the sampling of gases and of oil from oil-filled electrical equipment and for the analysis of free and dissolved gases

Process monitoring & Safety measures

Monitoring of contamination during the integrated treatments

Sea Marconi developed field kits to measure (and check) some oil parameters during the process

**Kit for
Total Chlorine/PCB**



SM-TCPs

**Kit for
Total Corrosive Sulfur**



SM-TCS

**Kit for
Total Acid Number**



SM-TAN

Process monitoring & Safety measures

Monitoring of integrated treatments

A Logical Process Control system (PLC) assures the monitoring of the process independently by the presence of the operator.

In case of abnormal conditions, oil circulation is automatically stopped

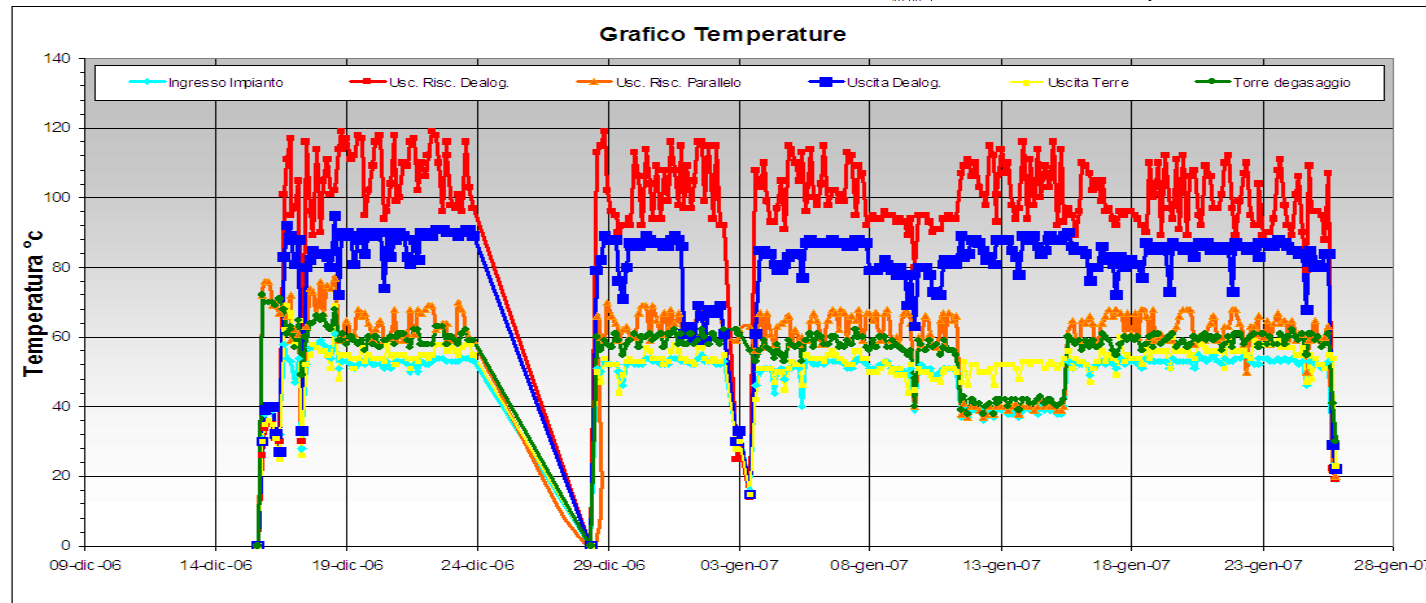
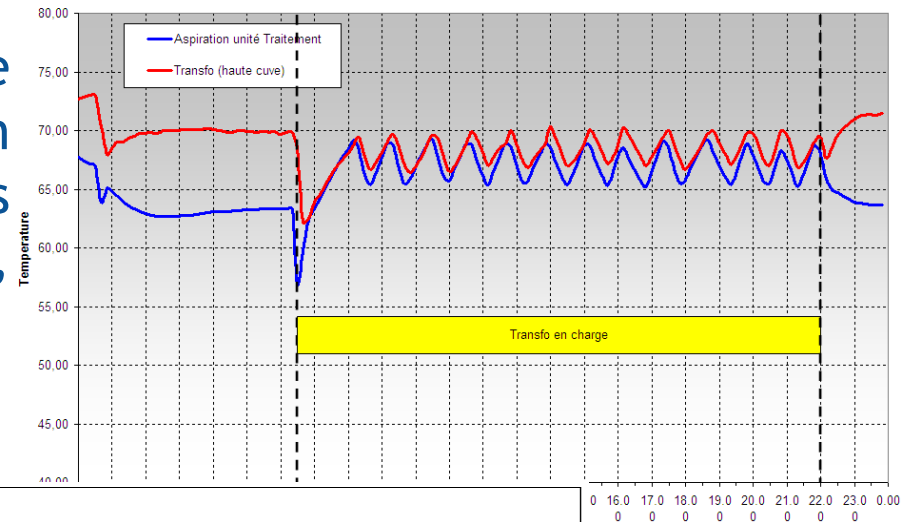
**SAFETY
MEASURE**



Process monitoring & Safety measures

Data recording during the integrated treatment

The PLC system ensure the monitoring and the log of the main parameter of the process, such as temperature, pressure, flow rate , ect

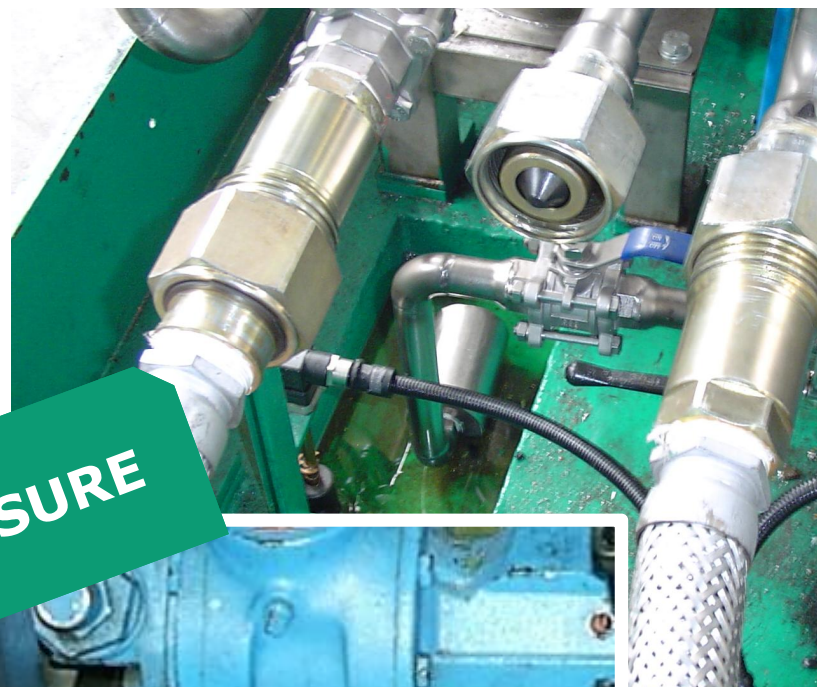


Process monitoring & Safety measures

Protection system of the integrated treatment

DMU and stationary units are also equipped with smoke sensors and spill protection devices.

All the connection point, pipes and joint are located into containment pans equipped with floating level switches



SAFETY MEASURE



Process monitoring & Safety measures

Integrated treatment, self cleaning system

The hydraulic circuit of the DMU units are designed to allow to exclude the oil circulation toward the transformer to execute the self cleaning procedure.

Every time the circuit is open (filters, reagent or filtration support replacement) the oil circulation toward the transformer is excluded and the DMU performs a self cleaning procedure.



All the possible contaminants (air, dust, etc.) that can be introduced in the circuit are eliminated by the unit itself through filtration, degassing and dehumidification.

Process monitoring & Safety measures

Personnel requisites

Safety requisites

During the operations the safety distances from the electrical part are respected. All technicians have to be trained according the international standards like CEI EN 50110.



Quality requisites

Sea Marconi has a quality system in accordance to the ISO 9001:2008 standards; the system includes procedures, instructions, forms for data collecting, check lists, etc.

Sea Marconi has been qualified as supplier for several major company in Europe, such as by EDF Nuclear department.

1st CASE HISTORY

PCBs/POPs Free & Environmental Protection CYPRUS 1996

Elimination of PCBs from the insulating oil of distribution transformers -
Electricity Authority of Cyprus (Sea Marconi awarded the tender)

Total Transformers = 520

➔ **Solutions: DMU & PCBs Dehalogenation (CDP Process®)**

Power max [KVA]: 10 - 1000

Voltage max [KV]:

Mass of contaminated oil [Kg]: 94,000

PCBs range [mg/Kg]: 50 - 15,000

PCBs target [mg/Kg]: < 10

Result: saving of 2 million USD

(avoided transformer replacement and waste disposal)



2nd CASE HISTORY

PCBs/POPs Free & Environmental Protection FRANCE 2004-2012

Utility - Power transformer of generation (nuclear, thermal, hydro),
transmission and distribution

Total Transformers = 1,093

➔ Solutions: DMU & PCBs Dehalogenation (CDP Process®) + Selective
Depolarisation (Chedcos®) On Load/ Off Load

Power max [MVA]: 760

Voltage max [KV]: 400

Oil Mass [Kg]: 75,000 each

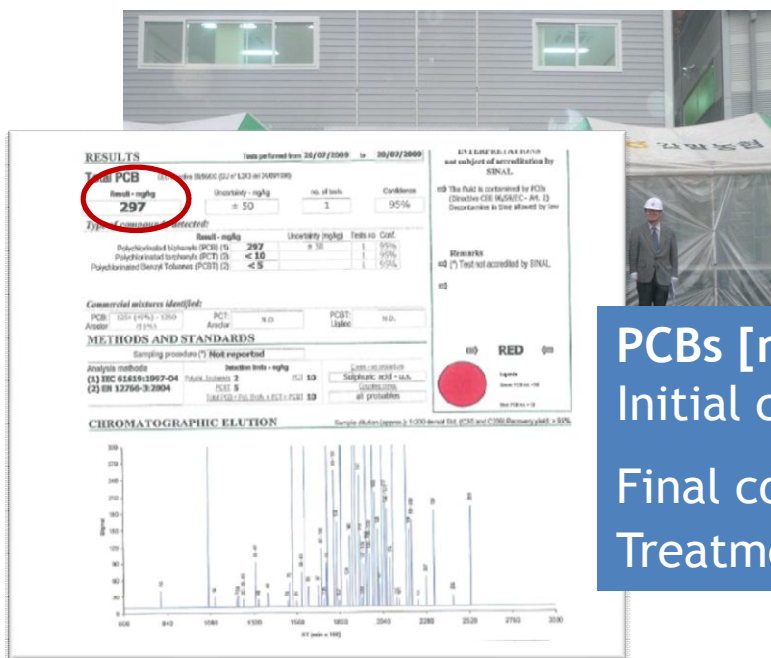
PCBs max [mg/Kg] = **5,000**

PCBs target [mg/Kg] = **<20** (after 90 days)

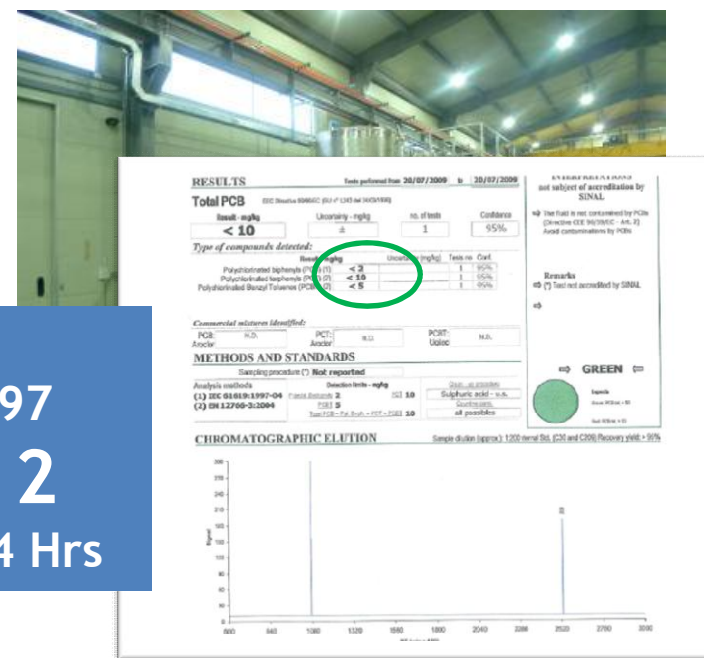


3rd CASE HISTORY

PCBs/POPs Free & Environmental Protection GreenField Project, South Korea 2010



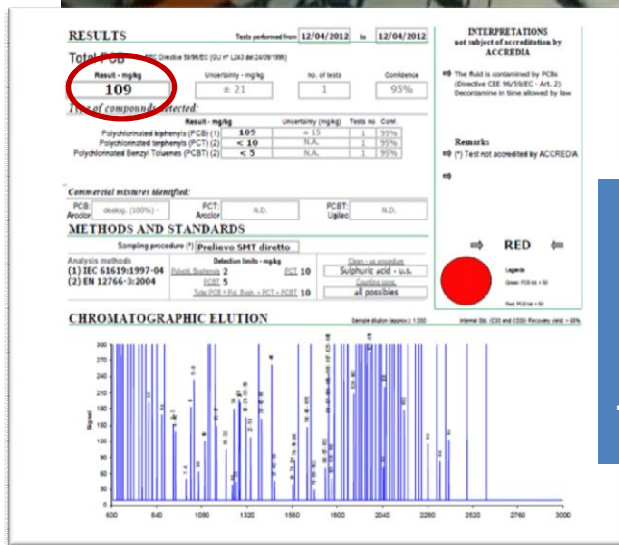
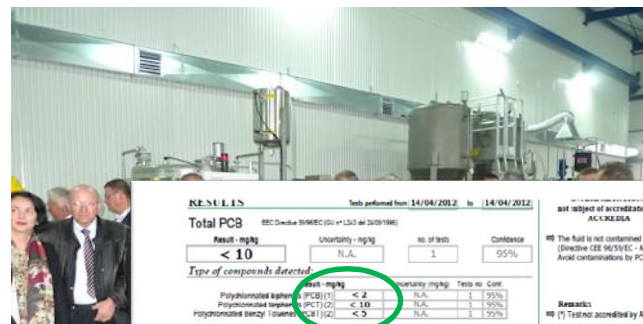
PCBs [mg/Kg]
Initial contaminat.: 297
Final contaminat.: < 2
Treatment duration: 4 Hrs



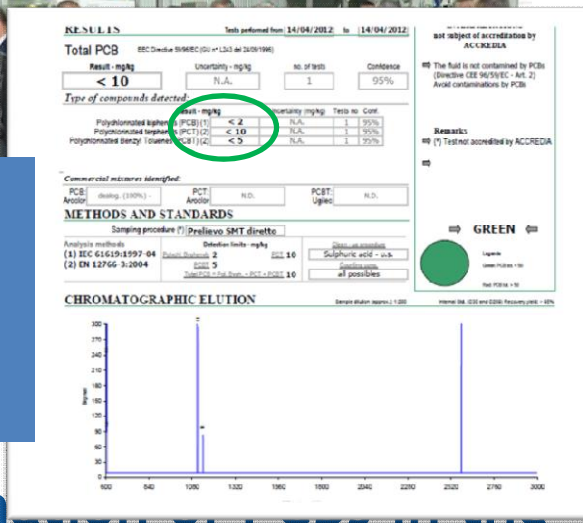
Stationary Plant for decontamination and re-valorisation of transformers contaminated by PCBs

4th CASE HISTORY

PCBs/POPs Free & Environmental Protection UNIDO Project, Macedonia 2012



PCBs [mg/Kg]
Initial contaminat.: 109
Final contaminat.: < 2
Treatment duration: 6 Hrs



oil of transformers

Mentioned as CASE OF SUCCESS to the last Conference of the Parties to the Basel Convention in Geneva (Switzerland) in May 2015

5th CASE HISTORY

PCBs/POPs Free & Environmental Protection UNIDO Project, Mongolia 2012



6th CASE HISTORY

PCBs/POPs Free & Environmental Protection SESA Project, Mexico 2013



6th CASE HISTORY

PCBs/POPs Free & Environmental Protection SESA Project, Mexico 2013

Tanks with 400 ton of oil decontaminated during 1 month

Duration: from Feb 12, 2013 to Mar 12, 2013

PCBs - starting value (average): **100** mg/Kg

PCBs target [mg/Kg] = **< 50** mg/Kg

Performance of the treatment (average) = 12 ton/day



1 treatment = many solutions at the same time

The DMU allow integrated treatments

According with CENELEC 50503, IEC 60422, CIGRE Brochure no. 413/2010

Main function	Physical decontamination	CHEDCOS depolarisation	CDP PROCESS® dehalogenation
Recovery of dielectric properties	●	●	●
Recovery of the chemical properties of the oil (acidity, delta tg, colour)		●	●
Elimination of DBDS (main responsible of corrosive sulfur problem)		●	●
Elimination of dissolved organo-metallic contaminants		●	●
Dehalogenation / Detoxification of PCB/PCT/PCBT , POPs, compounds etc.			●

1 treatment = many solutions at the same time

Chedcos® (Selective Depolarization)

The Selective Depolarization (Chedcos®) is performed using Decontamination Mobile Units (DMU) by Sea Marconi + patented solid reagent (S/Ched®).

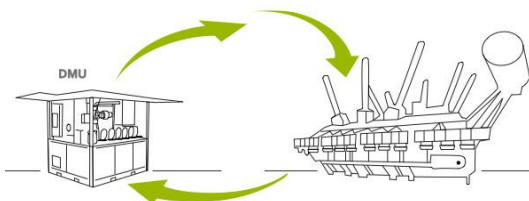


Chedcos is the exclusive technology for **corrosive sulfur** decontamination and DBDS removal

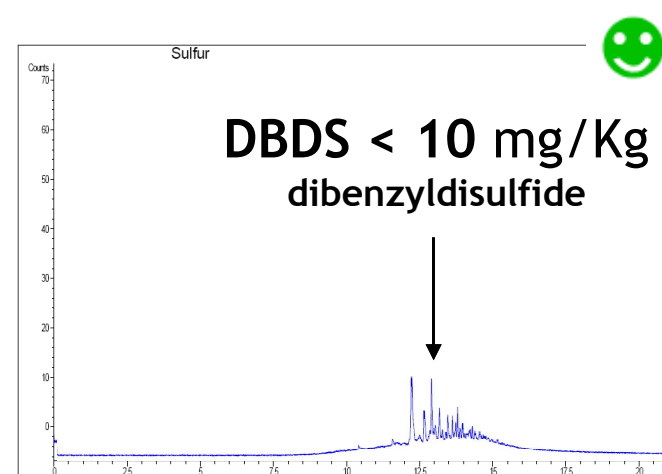
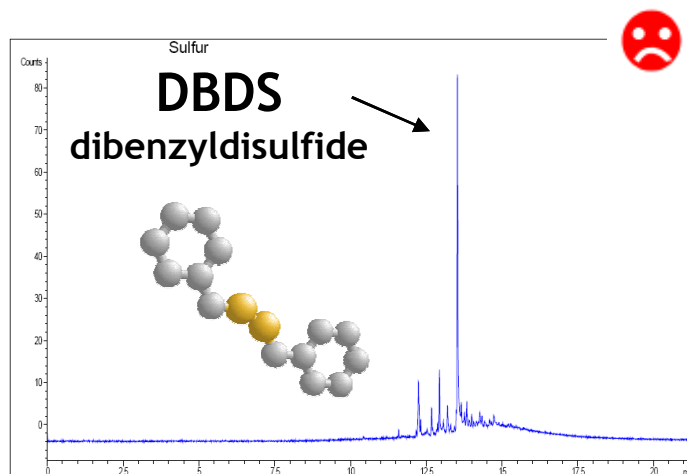
Chedcos is effective non only against Corrosive sulfur due to DBDS, but also against the other type of corrosiveness

Chedcos®: Selective Depolarisation treatment

**Before Selective
Depolarisation**



**After Selective
Depolarisation**



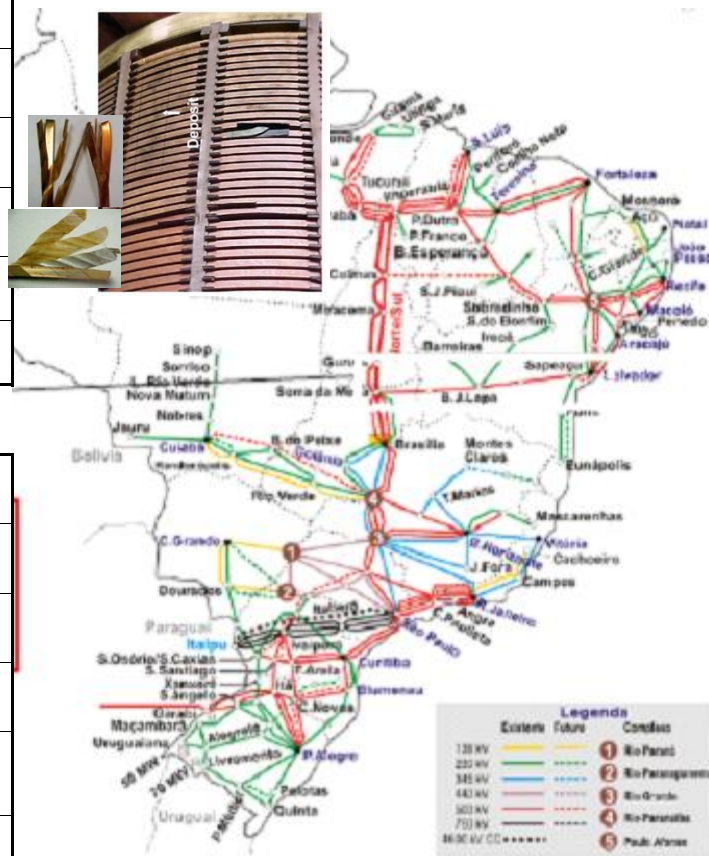
7th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» BRAZIL 2005

Transmission system: 76 Equipment

TSN	
Lines	1181 km
Substations	6
Total reactors	40
Reactors with corrosive sulfur	37 (92,5%)
Total failed reactors	15 (37,5%)

Novatrans	
Lines	1278 km
Substations	6
Total reactors	36
Reactors with corrosive sulfur	13 (36,11%)
Total failed reactors	-

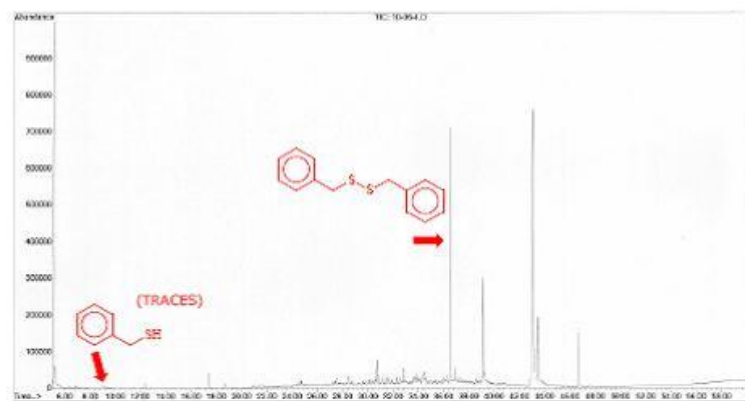


7th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» BRAZIL 2005

Transmission system: 76 Equipment

DBDS identification
by Sea Marconi lab (GC-MS) - July 2005



DBDS (DiBenzylDiSulfide) in Oil “Sulfur compound, very corrosive to metal surface (i.e. steel, copper and silver) at normal operating temperatures”

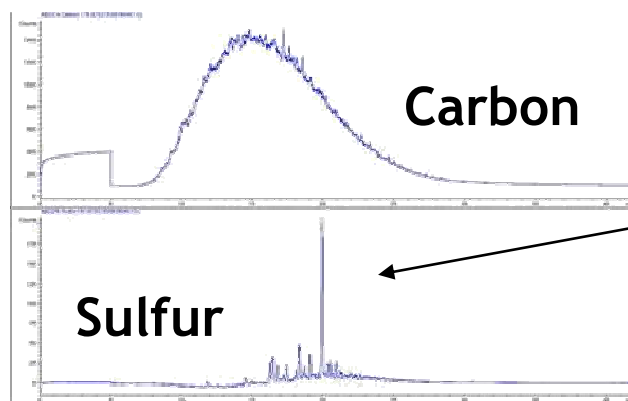
7th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» BRAZIL 2006

Transmission system: 76 Equipment

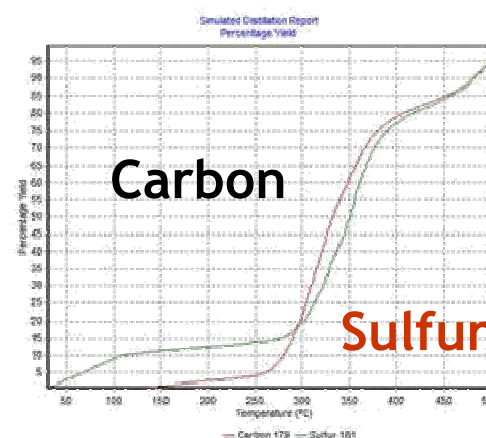
DBDS confirmation by Sea Marconi Lab (GC-AED)

SM-IFED Results: “Naphthenic Base Oil with **DBDS**” - **NYTRO 10 GBN**



IFED with GC-AED
fingerprint
DBDS

Distillation profile



Percentage Yield Table		
	Carbon 179	Sulfur 181
Temp. (Deg. C)	Temp. (Deg. C)	Temp. (Deg. C)
100% 0.1%	134.00	80.00
9.00%	261.00	60.00
10.00%	262.00	100.00
11.00%	263.00	110.00
22.00%	264.00	120.00
25.00%	265.00	130.00
30.00%	266.00	140.00
35.00%	267.00	150.00
40.00%	268.00	160.00
45.00%	269.00	170.00
50.00%	270.00	180.00
55.00%	271.00	190.00
60.00%	272.00	200.00
65.00%	273.00	210.00
70.00%	274.00	220.00
75.00%	275.00	230.00
80.00%	276.00	240.00
85.00%	277.00	250.00
90.00%	278.00	260.00
95.00%	279.00	270.00
100.00%	280.00	280.00
Total Carbon 179: 8246.100 %		
Total Sulfur 181: 100.00 %		

7th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» BRAZIL 2009

➔ Solutions: DMU & Selective Depolarisation (Chedcos®) on-load/off-load

Before depolarisation

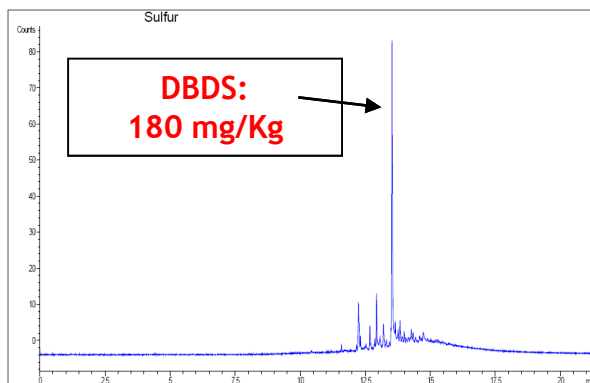


ASMT Scale: 4c

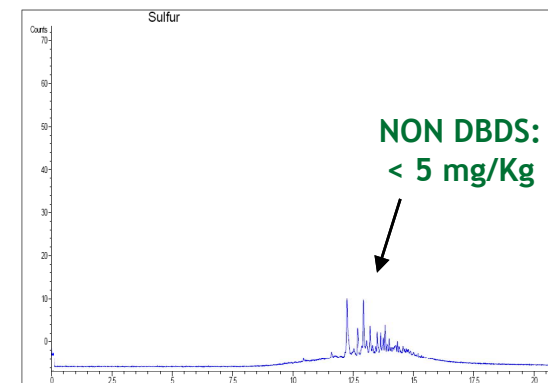
After depolarisation



ASMT Scale: 1a



DMU



Successfully implemented on all fleet of Transformer and Reactors

8th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2005

Thermal Power Plant: 4 GSU Transformers

Step 1	May 2005. Diagnosis and Prognosis Corrosivity index = 1 (max) ASTM b 48H= 4C System index 0.52 (52%)
Step 2	15 th April 2006 FAILURE D2 Discharges of high energy System index 0.80 (80%)
Step 3	May 2006 Visual Inspection and post failure diagnosis
Step 4	November 2006 Selective Depolarization

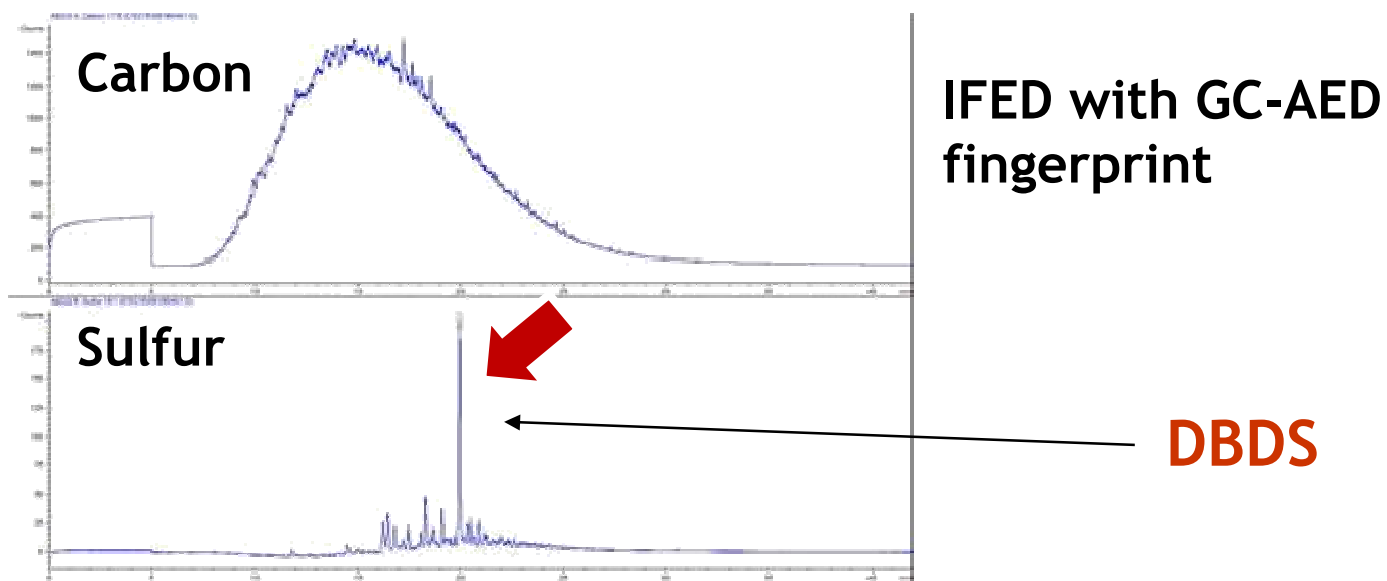
Manuf.: ABB
Year: 1997
Power [MVA]: 192
Voltage [KV]: 400
Oil Mass [Kg]: 58,000
Oil type: Naphtenic Oil

8th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2006

Thermal Power Plant: 4 GSU Transformers

SM-IFED Results: “Naphthenic Base Oil with DBDS”-



8th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2006

Thermal Power Plant: 4 GSU Transformers

Total estimated losses
(direct and undirect):
more than 20 mln €

Internal view of the HV winding,
failure zone



GSU Transformer 400 KV,
192 MVA, **Naphtenic Oil**



Extraction of core and windings on 19th April 2006 for VISUAL INSPECTION

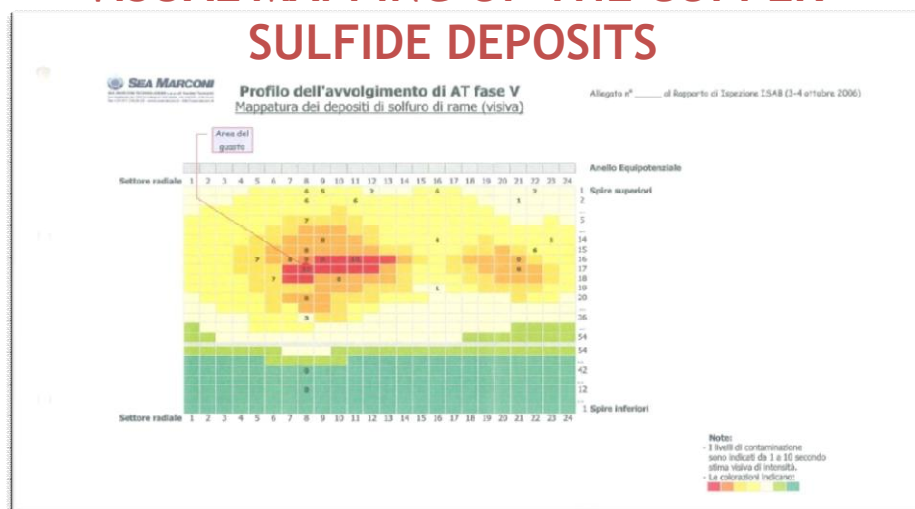
8th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2006

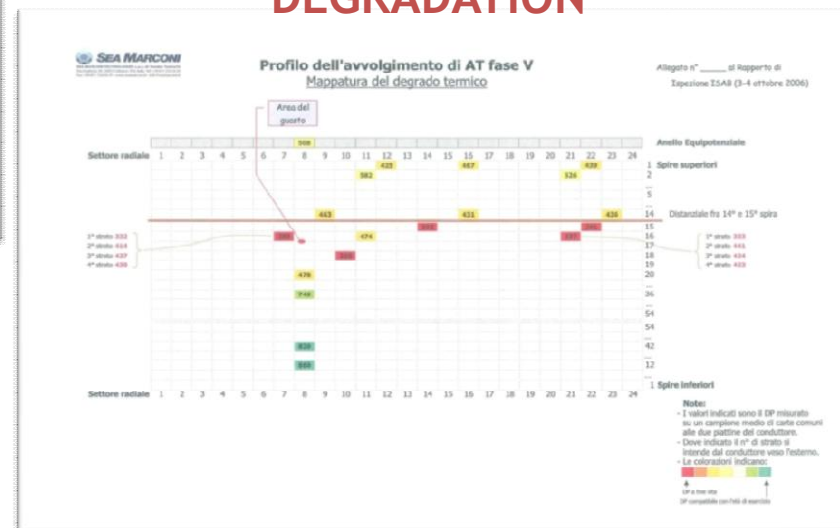
Thermal Power Plant: 4 GSU Transformers

GSU Transformer 400 KV,
192 MVA, **Naphthenic Oil**

VISUAL MAPPING OF THE COPPER SULFIDE DEPOSITS



MAPPING OF THE THERMAL DEGRADATION



8th CASE HISTORY

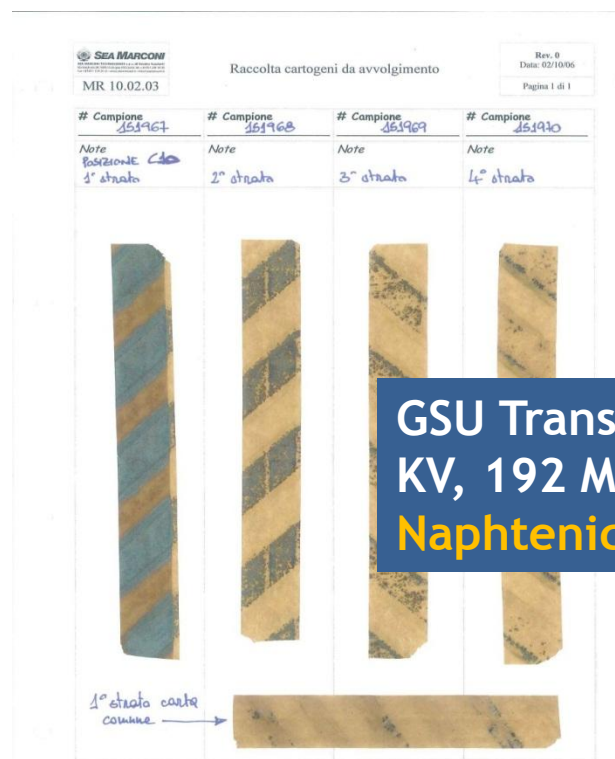
«C1 - DBDS & Corrosive Sulfur» ITALY 2006

Thermal Power Plant: 4 GSU Transformers

COLLECTION OF PAPERS FROM THE WINDING

- Internal conductors of the winding heavily contaminated by copper sulfide.

The strong corrosiveness of the oil (corrosiveness code: 4c, by repeated analyses according to ASTM D 1275 A ext. 48h) caused the deposition of elevated amounts of copper sulfide on the paper components.



GSU Transformer 400 KV, 192 MVA, Naphtenic Oil

8th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2006

Thermal Power Plant: 4 GSU Transformers



Solutions: DMU & Selective Depolarisation (Chedcos®) on-load

Type: GSU Power Transformer

Manuf.: ABB

Year: 1997

Power [MVA]: 192 MVA

Voltage [KV]: 400 KV

Oil Mass [Kg]: 58.000 Kg



	DBDS [mg/Kg]	IFT [mN/m]	TAN [mg KOH/g]	DF
Before treatment	110	17	0,133	0,0448
After treatment	< 5	40	< 0,01	0,0118

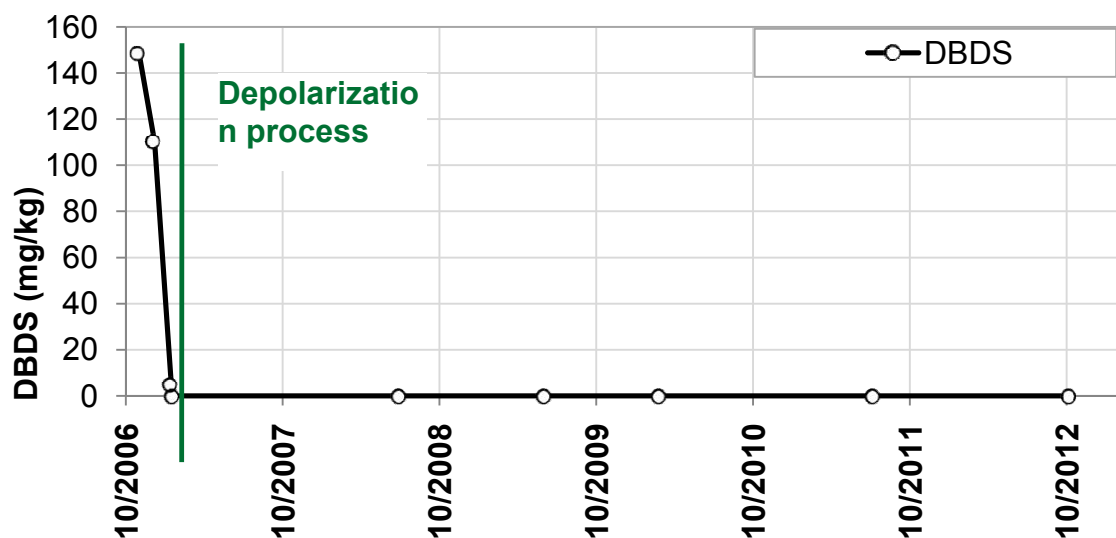
Successfully implemented on all fleet of Transformers

8th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2006/2012

Thermal Power Plant: 4 GSU Transformers

➔ Solutions: DMU & Selective Depolarisation (Chedcos®) on-load long terms performance



GUARANTEE: DBDS < 10 mg/Kg after Selective Depolarization

9th CASE HISTORY

«C1 - DBDS & Corrosive Sulfur» ITALY 2009-2013

National Transmission Utility

Total Transformers = 36

➔ Solutions: DMU & Selective Depolarisation (Chedcos®) On Load/ Off Load

Power max [MVA]: 528
Voltage max [KV]: 400
Oil Mass [Kg]: 96,900 each
DBDS max [mg/Kg] = **185**
DBDS target [mg/Kg] = **< 5**



10th CASE HISTORY

PCBs + «C1 - DBDS & Corrosive Sulfur» SWEDEN 2012

Primary aluminium factory: 8 Rectifier Transformers

➔ Solutions: DMU & PCBs Dehalogenation (CDP Process®) + Selective Depolarisation (Chedcos®) On Load

Manuf.: Brown Boveri

Year: 1930

Power [MVA]: 19

Voltage [KV]: 13

Oil Mass [Kg]: 15,000

Oil type: mineral blended



	PCBs [mg/Kg]	DBDS	IFT [mN/m]	CCD test	TAN [mg KOH/g]	DF
Before treatment	29	18	24	corrosive	0,34	0,230
After treatment	0,37	< 5	42	non corrosive	0,01	0,002

GUARANTEE: PCBs < 2 mg/Kg

11th CASE HISTORY

PCBs + «C2 - NON DBDS & Corrosive Sulfur» FRANCE 2012

Hydro Power Plant: 3 GSU Transformers

➔ Solutions: DMU & PCBs Dehalogenation (CDP Process®) + Selective Depolarisation (Chedcos®) On Load

Manuf.: Alsthom

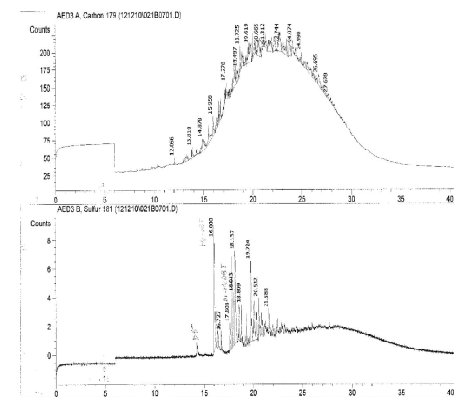
Year: 1965

Power [MVA]: 80

Voltage [KV]: 220

Oil Mass [Kg]: 35,000

Oil type: naphtenic blended Oil



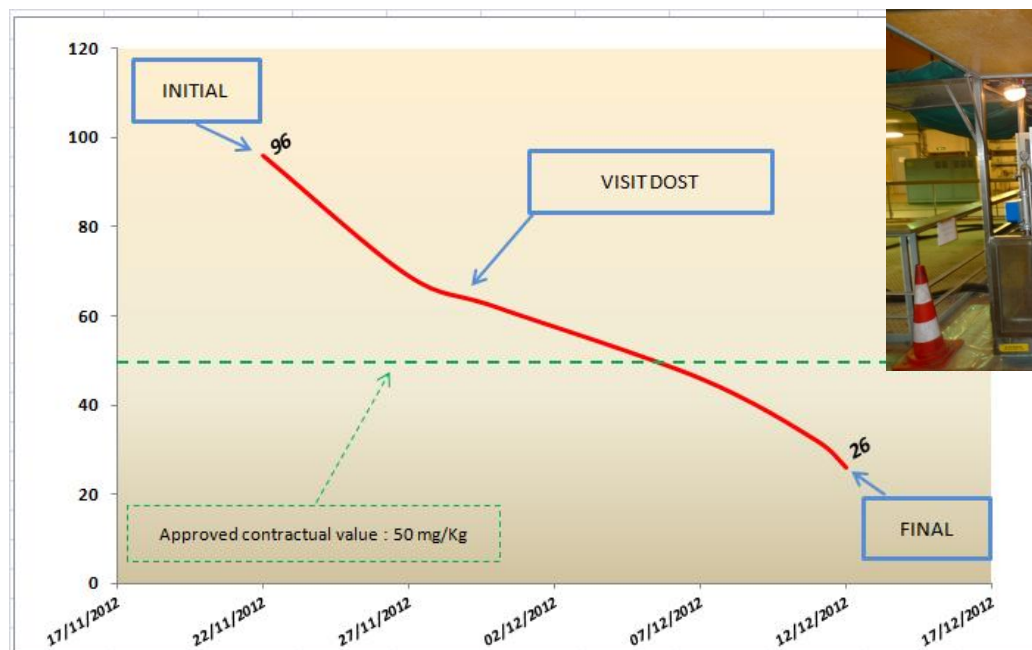
	PCBs [mg/Kg]	TCS DBDS Eq. [mg/Kg]	CCD	DBTP [mg/Kg]	TAN [mgKOH/g]	DF
Before treatment	96	64	Corrosive	16	0.194	0.13737
After treatment	26	<10	Non corrosive	14	0.01	0.05144

11th CASE HISTORY

PCBs + «C2 - NON DBDS & Corrosive Sulfur» FRANCE 2012

Hydro Power Plant: 3 GSU Transformers

➔ Solutions: DMU & PCBs Dehalogenation (CDP Process®) + Selective Depolarisation (Chedcos®) On Load



12th CASE HISTORY

PCBs + «C2 - NON DBDS & Corrosive Sulfur» MEXICO 2014

➔ Solutions: DMU & PCBs Dehalogenation (CDP Process®) + Selective Depolarisation (Chedcos®) On Load

Type: Grid Transformer
Manufact.: L
Year: 1969
Power [MVA]: 100
Voltage [KV]: 229
Oil mass [Kg]: 32,750
Oil type: mineral (nafthenic)



	PCBs [mg/Kg]	Total corrosive sulfur (DBDS eq.) [mg/Kg]	water [mg/Kg]	IFT	Color	Metanol [ng/g]	TAN [mgKOH/g]
Before treatment	38	16	11	35	0,6	1.095	< 0,01
After treatment	8	< 5	8	42	0,5	10	< 0,01

13th CASE HISTORY

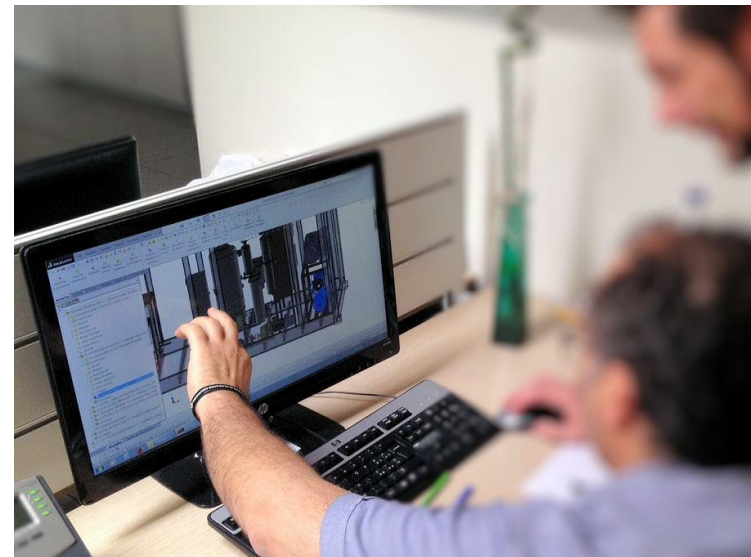
Japan 2015



Sea Marconi is realizing a mobile plant (40 feet containerized) for decontaminate Oil & Transformer with PCBs

EXTRAORDINARY PERFORMANCE: PCBs < 0,5 mg/kg

Sea Marconi has done an enormous **redesign** job coming to define a **new technological concept**: lighter and smaller, schemes fluidic optimized, higher performance, optimizing the use of materials



14th CASE HISTORY

United Kingdom 2015



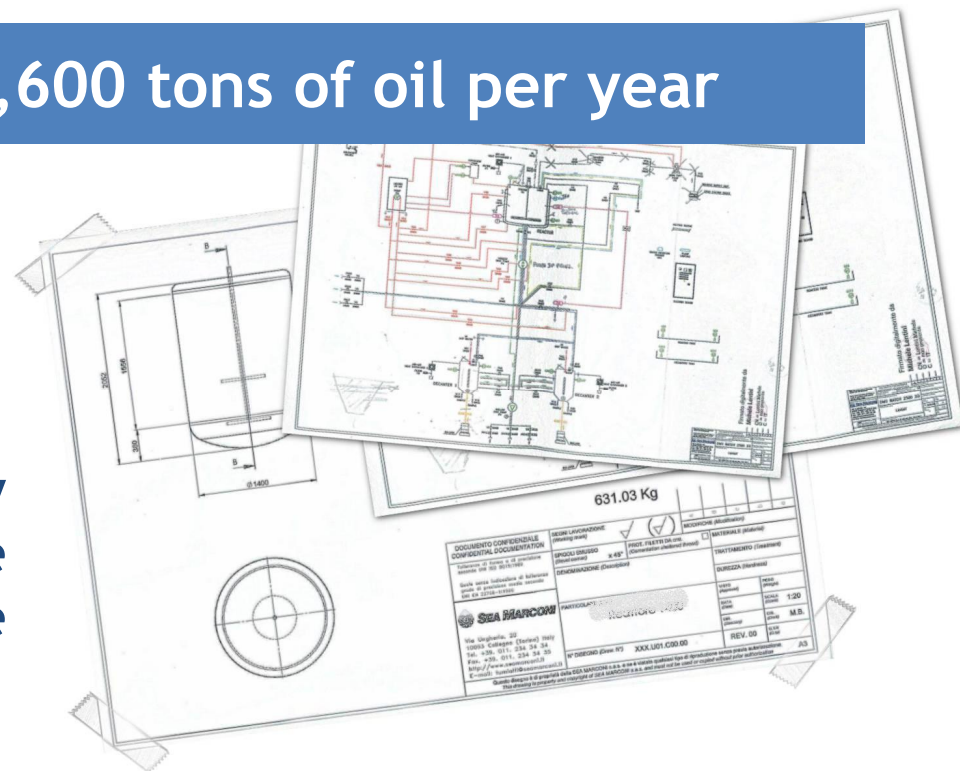
Sea Marconi is realizing a stationary plant for decontaminate (and recycle) Oil with PCBs and corrosive sulfur

Treatment capacity: 4,600 tons of oil per year

PCBs target [mg/Kg] = < 2

DBDS target [mg/Kg] = < 5

The plant will be easily expandable to accommodate the treatment capacity of the customer (15,000 tons/year)



Worldwide Sea Marconi Experience

FOCUS on LATIN AMERICA

- 1 DMU in Mexico + 4 more plants scheduled in the next 10 years
- Starting from May 2014: 2 DMU in Brazil against corrosiveness
- 3 DMU in Argentina
- 1 DMU in Colombia por 4 months
- 1 DMU in Chile for 6 months
- From the end of 2015, 1 DMU in Uruguay for 1 year

📍 Treatments performed by Sea Marconi

📍 Treatments performed by Sea Marconi partners

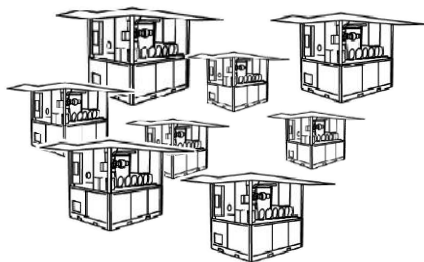


Main References in Europe

- **EDF (France):** Framework agreement for PCBs decontamination of about **200** power transformers every year (since 2003)
- **SNCF (France):** Framework agreement for PCBs decontamination (since 2007)
- **ENEL (Italy):** more than **200** power transformers decontaminated (since 1993)
- **Endesa (Spain):** **30** power and distribution transformers decontaminated (2007-2009)
- **C.E.R.N. (Switzerland)**

... And more than 8.000 power transformers decontaminated in the last 25 years

Industrial capacity of Sea Marconi



41 Plants realized in the last 20 years

27* Plants realized in the last 10 years

FLOW RATE

4.000 l/h (Average)

15.000 l/h (Max)

300 l/h (Min)

CONFIGURATION

- Mobile Units
- Stationary plant

TRANSPORT METHODS

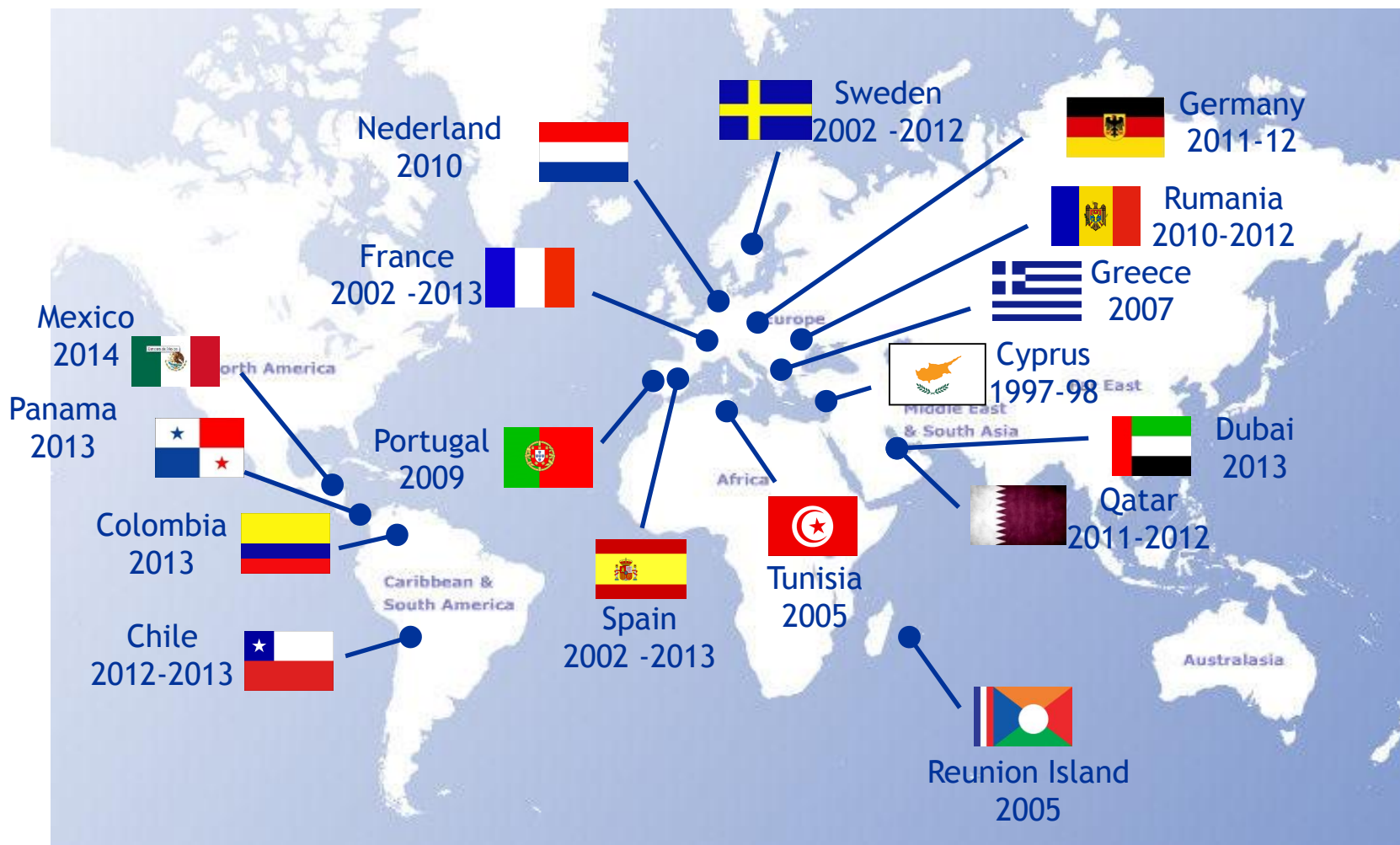
- Containerized
- Open top skid
- Pickup trailer
- Small size easy handling



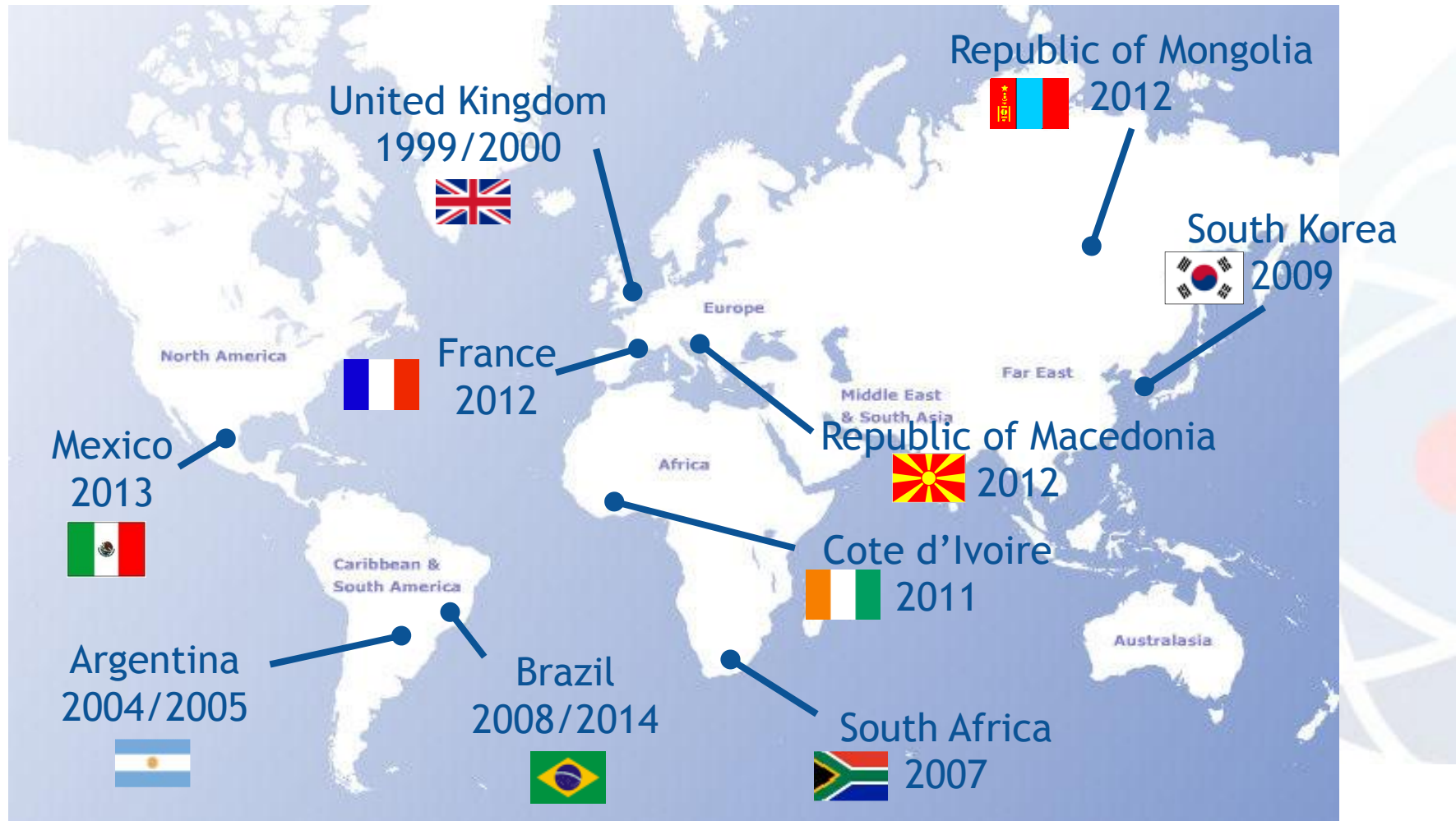
***All 27 plants have been sold to customers or international partners**



Worldwide On Site Service



Technology Transfer to Customers/Local partners



Conclusions

CDP Process®: PCBs dehalogenation + Functional recovery/reuse of operational transformers

1. Non-Combustion Technology, no explosion risks, no leakage risk
2. Target: transformers and insulating liquids contaminated with up to 50.000 ppm of PCBs
3. PCBs destruction → PCBs-free waste
4. On-site application without draining of transformer
5. Well proven Technology: more than 25 years experience and 8.000 transformers treated
6. Transformers energized and on-load during the process
7. Sea Marconi: technological partner of top-level companies worldwide
8. CDP Process®: Best Available Technology (BAT) - BEP for PCBs decontamination of electrical equipment

Conclusions

Sea Marconi Solutions for Loss prevention & Environmental protection

Key Factors

- a. State of the Art (2015)
- b. Technical Standards (IEC, CENELEC, etc.) and Guidelines (CIGRE, etc.)
- c. Best Available Techniques (BAT)
- d. Best Environmental Practices (BEP)
- e. Accredited Laboratories (ISO IEC 17025) with uncertainty determination for each Test
- f. Qualified Expertise based on a robust database and Case Histories

Conclusions

The Sea Marconi solutions for Loss Prevention & Environmental protection can prevent and/or mitigate the potential losses and unreasonable risks for the asset, workers, public health and environment.

These solutions are targeted for protection of specific fleet of strategic electrical equipment filled with insulating fluids.

This approach guarantees knowledge added value for Customers, Holders and Partners in terms of best innovative technologies, reliability, quality control, traceability, economics, environmental protection, social and stakeholders relationship.



Thank you for your kind attention



Q & A



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Sustainable Solutions for Energy and Environment

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