DESTRUCTION TECHNOLOGIES

FOR

POLY CHLORINATED BIPHENYLS (PCBs)

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Guidance from Stockholm Convention

Based on provisions for POPs disposal, a technology should:

- Prevent the formation of dioxins, furans and other byproduct POPs.
- Prevent the release of dioxins/furans and other by-product POPs.
- Not generate any wastes with POPs characteristics.
- Not utilise any POPs disposal methods which are nondestructive, such as landfilling or recycling in any form.

Technical Criteria

Complete destruction of the PCBs

Commercially available and proven track record

Prevent the formation of dioxins, furans and other by-product POPs.

Not generate any waste with POPs characteristics.

Destruction Efficiency

- Destruction Efficiency (DE) ~ is calculated on the basis of the total mass of POPs fed into a process, versus the sum of the POPs in all products, by products, and environmental releases (eg. gaseous, solid and liquid) ie. DE considers the total destruction in a given process
- Destruction and Removal Efficiency (DRE)

DE and DRE are normally reported as a percentage

Evaluating Technologies

- Based on Stockholm Convention criteria
- Destruction Efficiency (based on inputs vs. all outputs)
- Ability to contain all process streams
- Ability to reprocess materials, residues, gases, liquids if required
- Availability of complete process information Track record / commercial availability
- Safety/Occupational Health and Safety
- Hazardous materials use
- Community acceptability and participation

Summary of PCB Disposal Technologies

Gas Phase Chemical Reduction (GPCR)	Incineration
Base catalysed dechlorination	Vitrification
Solvated electron technology	Deep well injection
Sodium reduction process	Plasma
Electrochemical	Solvent washing
Super-critical water oxidation	Land fill /burial
Ball milling	Solidification / stabilization
Molten salt	Land spreading
Catalytic hydrogenation	Molten metal

Technology	Commercial scale	Countries Utilysed
Gas Phase Chemical Reduction (GPCR)	Full	Australia,Canada,USA,Japan
Sodium reduction	Full	France,Germany,UL,Netherlands, South africa,Australia,USA,Soudi Arabia,Japan,New Zealand
Base catalysed dechlorination	Full	Australia, USA,Mexico,Spain,New Zealand,Japan.
Solvated electron	Full	USA
Electrochemical	Limited	USA
Catalytic hydrogenation	Limited	Australia
Super-critical water oxidation	Limited	USA,Japan.
Plasma	Operational	Australia

Landfill and deep well injection

It is the most common forms of remediation technologies.
It can be temporary or permanent
But, it is not the destruction technology, it is only a method of containment.
Injection of hazardous chemicals deep wells is not widely accepted technology.
There are chances of migration and difficult to track the their movement.

Cement Kilns

- Commercial system not design as a waste treatment process, but with capability to destroy some wastes
- Large rotary kiln
- Meets residence time and temperature requirements
- Allowed in certain jurisdictions (USA) to burn PCB contaminated mineral oil with concentration below 500 ppm
- They are not permitted to burn oil with PCB level above 500 ppm or Askarels

Gas Phase Chemical Reduction (GPCR)

Process: Hydrogen reacts with chlorinated organic compounds, such as PCBs, at high temperatures (850oC)/low pressure (atmp) yielding primarily methane and hydrogen chloride. 40% methane is converted to Hydrogen and reused Efficacy: Demonstrated high destruction efficiencies for PCBs, dioxins/furans, HCB, DDT. Applicability: All POPs – including PCB transformers, capacitors, and oils. Capable of treating high strength POPs wastes. May not be economic for low level wastes Licensed: Australia, Canada, USA, Japan

Base Catalyzed Dechlorination (BCD)

Process: A non-conventional heterogeneous catalytic hydrogenation process which reacts organochlorines with an alkali metal hydroxide, a hydrogen donor and a proprietary catalyst to produce salts, water and carbonaceous residue.

Efficacy: High destruction efficiencies have been demonstrated for DDT, PCBs and dioxins/furans.

Applicability: DDT, PCBs, dioxins/furans. Limited to approximately 15-30% strength PCBs.

Base Catalyzed Dechlorination (BCD)

Emissions: Solid residues may be captured for assay and reprocessing if needed.

Concerns: Solid residues not fully defined. Potential for emissions through pressure relief valve.

Applicability under Stockholm Convention for POPs destruction: potentially suitable if operated to maximum treatment effectiveness.

Licensing: Commercially licensed in USA, Australia, Mexico (S.D Meyers), Japan and Spain(IHOBE S.A.).

Vendor: BCD Group Inc., Cincinnati, OH, USA,

Molten metal pyrolysis

- The molten metal acts as both solvent and catalyst.
- Molten metal Tech Inc (MMT) uses molten iron and other metals to convert waste into useful material.
- Molten metal heated to 2400F to 3000F and this breakdown the chemical compounds in to primary elements
- The elements are extracted as gases, ceramics and alloys.

- Gases: H_2, CO_2 and upto 1% ethylene and other light hydrocarbons
- Ceramics slag: silica, alumina and $CaCl_2$.

Bacteriological Processes

- Aerobic and anaerobic processes
- Based on natural occurring bacteria
- Mainly applied to soil
- Slow process
- More effective with low chlorinated PCB homologs

CDP process

(Chemical dehalogenation by percolation)

The process is connected to the transformer and in continuous mode and closed circuit, with circulation of warm oil, without requiring draining. This process uses granular solid reagent (polyethyelene glycols and polypropylene glycols with high molecular weight) , a mixture of bases & a radical initiator. The insulating liquid is heated at a temperature between 80 and 100oC and undergoes chemical dehalogenation by percolation under pressure on the solid reagent. Efficiency is 99.9% The technology is well established.

Supercritical water oxidation

Treating waste in enclosed system, using an oxidant in water at temperatures and pressures above the critical point of water (374oC and 218 atmp).

Organic materials become highly soluble in water and get oxidized.

Oxidants used: O_2,H_2O_2, O_2/H_2O_2.

Carbon
H_2
Cl^2
Nitro
Sulfur
Phosphorus

→

CO_2
H_2O
Cl^-
Nitrates
Sulphates
Phosphates

The effluent gases contains no oxides of nitrogen or HCl/H_2SO_4. Less than 10ppm of CO has been measured.

Efficiency is 99.999%

Sodium-Based Technologies

- *Advantages*
  – Allows recycling and re-use of oil
  – Established track record with 100s of millions of mineral oil treated and reclaimed
  – Safe and simple technology
  – Can be made mobile or fixed, big or small
  – Low capital investment required
  – Low or non-emission
  – Can meet the most stringent requirements
- *Disadvantages*
  – Specific for oil
  – Can be expensive to apply to high level waste

Sodium reduction processes

Process: Reduction of PCBs with dispersed metallic sodium in mineral oil. Has been used widely for in-situ removal of PCBs from active transformers. Products of the process include non- halogenated polybiphenyl, sodium chloride, petroleum based oils and water (pH > 12).

RH 10-xClx + oNa -------> NaCl + o RH$_{10-x}$Cl$_{x-1}$

^{o}RH$_{10-x}$ Clx + oH ------>RH10-x+1Clx-1

where, oRH10-x Clx is a PCB molecule with x number of chlorine atoms and Na is metallic sodium

(eg. in Canada to [PCB] < 2 ppm for treated oil; and [PCB] < 0.5 ppm; [dioxins] < 1 ppb for solid residues).

Plasma Arc

- Creation of high-temperature (up to10,000oC) plasma arc
- Decomposes chemicals to atomic form
- Induced re-composition to desired material

Compared to incineration:

- Higher destruction efficiency
- Lower gas emission
- Lower capital and maintenance costs
- Smaller size (could be built mobile)

- Commercial systems:

- Plascon (Australia)
- Parcon (Canada)

Case Study - Australia

1970-80's attempts to build centralized High Temperature Incinerator (HTI) failed because of community opposition

Government decided to halt HTI proposal and promote non-incineration destruction technologies (1992)

Community involvement (NAB) and National Management Plans for PCBs, HCB, OCPs

All PCBs since early 1990's treated in Australia using commercial non-incineration technologies

Case Study - Japan

In 1989 Japan banned incineration of PCBs

In 1998 regulations amended to permit non-incineration destruction of PCBs

2001:

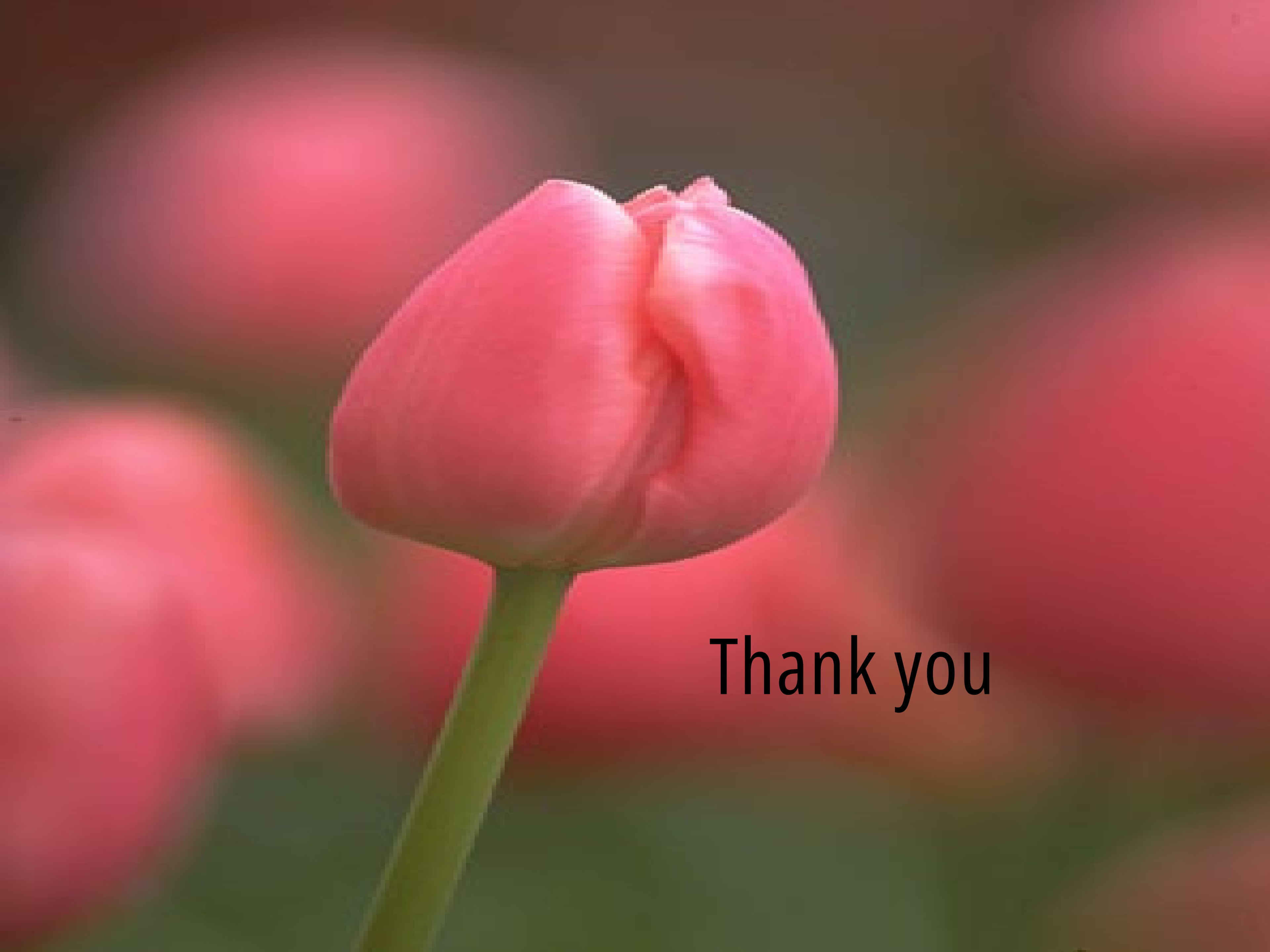
12 companies have licensed and/or developed nonincineration technologies for PCB disposal.

Summary

Technologies for PCB destruction should be capable of effectively 100% treatment efficiency, and containing all process streams for testing and reprocessing if necessary.

Non-incineration technologies have been demonstrated to effectively treat and destroy PCBs and other POPs.

Alternatives to incineration- Plasma one of the good option, which is commercially available.


Thank you