Plasma Arc (PLASCON)

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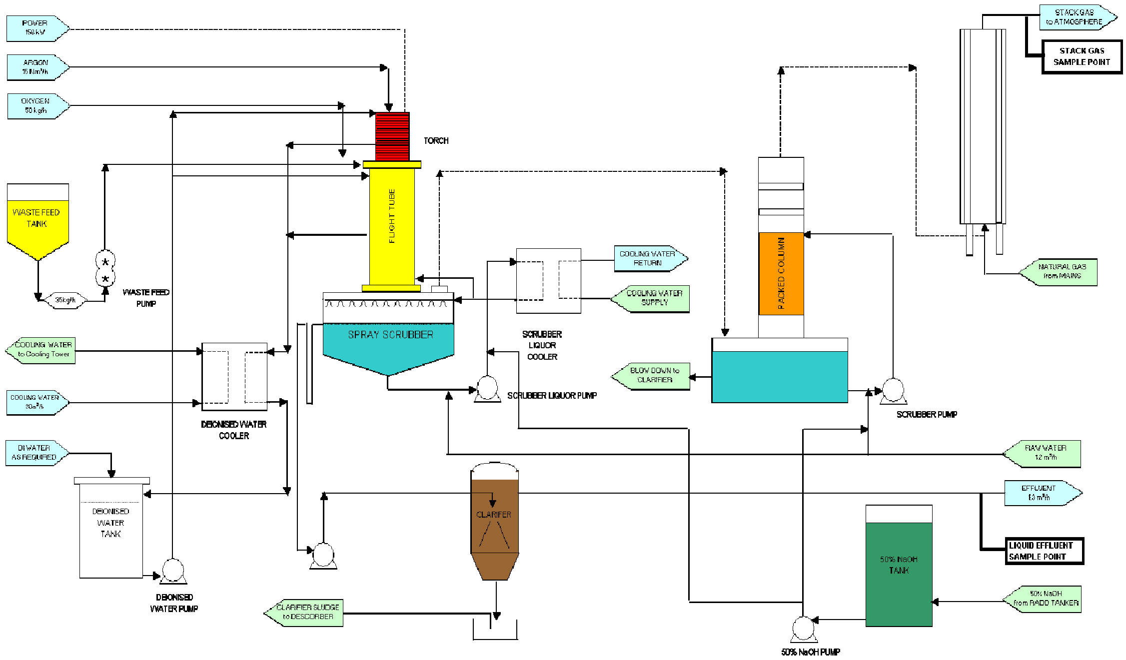
Name of Process:
Plasma-arc (PLASCON)

Applicable Pesticide and related POP wastes:
Pesticides such as HCB, DDT, Aldrin, Dieldrin, Lindane, 2,4 D, PCBs, Dioxins, furans and other compounds such as halons and chemical industry in-process waste streams

Status:
The "in-flight" plasma arc PLASCON technology has been operating commercially since 1992. To date there are 10 commercial plants operating with licences from the Victorian and Queensland EPA's in Australia, the UK EPA, the USA EPA, the Mexican EPA and the Japanese Ministry of the Environment. 4 commercial 150 kW PLASCON units are operating in Australia. 2 units were installed at the Nufarm Ltd Agricultural Chemicals in Melbourne in 1992/1993, which treat the liquid waste stream from 2,4 D manufacture which comprises 35 % chlorophenols, 45 % chlorophenoxies and 20 % added toluene to reduce the viscosity of the liquid. Each plant has a capacity of 1 t/d of waste and to date over 7000 tonnes of waste has been destroyed. One unit was installed in Melbourne in 1997 to destroy halons and freons. The 4th unit was installed at a facility in Brisbane to destroy concentrated PCB solutions (>10 %) as well as a range POP pesticides. To date over 2500 tonnes of concentrated PCBs and OCPs have been destroyed. One unit operated in the UK destroying fire retardants and ODS. After successful operations for 3 years, this unit was relocated to Mexico where it now destroys Green House Gasses for a major refrigerant manufacturer. ODS gasses are destroyed by a plant in Ohio. In Japan, a large chemical company has installed four PLASCON plants to destroy PCB wastes. The plants became operational in May 2004 and till April 2005 900 tonnes of waste has been destroyed. In July 2007, over 12 000 tonnes of mentioned wastes have been successfully destroyed.

Technology Description:
The PLASCON "in-flight" plasma-arc system was developed by the Commonwealth Scientific Industrial Research Organisation (CSIRO) and commercialised by an Australian company, via their subsidiary. In 2001 an Australian waste management company bought this subsidiary. The process develops a high temperature (>10 000 ^{0}C) plasma-arc by ionising argon gas using a 150 kW DC discharge between the cathode and the anode. The waste, as a liquid or gas is injected directly into the plasma and rapidly (<1 ms) heats to about 3100 ^{0}C and is pyrolysed for about 20 ms in the water-cooled reaction chamber (flight tube). To ensure no formation of soot a controlled amount of oxygen is injected into the plasma to convert any carbon to CO. At the end of the flight tube, the gas at about 1500 ^{0}C is rapidly (<2 ms) quenched to less than 100 ^{0}C in a direct spray condenser using an alkaline spray solution. The gas is further cooled and scrubbed of any remaining acid gases in a packed tower. These off-gases, which contain mainly CO and Ar are then flared to oxidise the CO to CO_2. Contaminants in solid and bulk wastes are thermally desorbed and condensed and then fed as a liquid to the PLASCON unit for destruction.

Process Diagram:



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PART I: Criteria on the Adaptation of the Technology to the Country

A. Performance:

1. Minimum pre-treatment:
The only real limitation of the process is that it can only process liquid or gaseous streams. Liquid streams should not contain particles greater than 0.5 mm in size. A Thermal Desorber is used to remove contaminants from solids. The contaminants are condensed and treated by Plascon in liquid or gaseous phase. Typical solids treated are: transformer and capacitor parts, protective clothing, contaminated drums and packaging and soil. Liquid POP's can be direct injected. POP's formulated with solids are desorbed first and then fed as liquid or vapour.

2. Destruction Efficiency (DE):
Commercial PLASCON plants have treated a wide range of Scheduled Wastes in Australia including most POP pesticides and PCBs as well as process waste streams from a pesticide manufacturer. Plants in both Australia and the UK are used to destroy halons and chloro-fluoro hydrocarbons. Commercial plants in Japan are used to destroy PCBs. Destruction efficiency for all these contaminants is typically greater than 99.9999%. A list of compounds treated is shown below.

Independent performance monitoring data has shown that DE's for POPs and ODSs (Ozone Depleting Substances) are consistently greater than 99. 9999%. The concentration of residual POPs in the treated effluent stream is typically not detectable, at a detection level of 0.5 µg/L and atmospheric emissions are typically less than 1µg/Nm^3. Dioxin emissions are typically less than 0.01 ng-TEQ/Nm^3 (see also Table 1 and Table 2 of Annex).
Japanese control levels to the treated effluent streams (gas and liquid) are very rigorous. Our facilities have adsorption vessels of activated carbon treatment for both gas and liquid effluent streams. PCBs removal rate from the concentrate solution to the effluent streams is typically greater than 99.999999%. (eight 9s).***

3. Toxic By-products:
Sodium Chloride and CO2

4. Uncontrolled releases:
None

5. Capacity to treat all POPs:

Compounds treated:

Industrial chemicals and manufacturing by-products/wastes
PCBs, Dioxins and Furans, waste chlorophenols (dichlorophenols and dichlorophenoxy acetic acids) from herbicide (2,4D) manufacture.

Commercial Pesticides			***Other Compounds treated***
Azinophos	DDE	Mitotane	Halons and chloro-fluoro hydrocarbons (ODS)
2,4 D	DDT	Nonachlor	toluene
2,4,5 T	Endosulfan	Permethrin	mineral oil
Carbaryl	Ethion	Oryzalin	chlorinated solvents
Chlordane	Heptachlor	Trifluralin	sulphur hexafluoride
Chlorpryifos	Limonene		mercaptans
Dichlorvos	Malathion		

6. Throughput:
6.1 Quantity [tons/day, L/day]
Each PLASCON unit can treat between 1 and 3 t/d of POP waste, depending on its strength and characteristics.

6.2 POPs throughput : [POPs waste/total waste in %]
POP's throughput is given on 2 examples: For waste with for example 5% DDT in 95% solids (lime, talcum powder) Plascon can treat about 20 t/d after desorbtion. For waste with 25 % DDT in 75% Toluene then Plascon can treat 1 t/d. PLASCON plants are supplied as skid-mounted units equipped with a 150 kW plasma torch. The plasma torch, water cooled reaction chamber (flight tube) quench and scrubbing system, power supply, associated pumps and process control system are mounted on the skid (see photo). The flare is provided as a separate fully engineered and controlled system.

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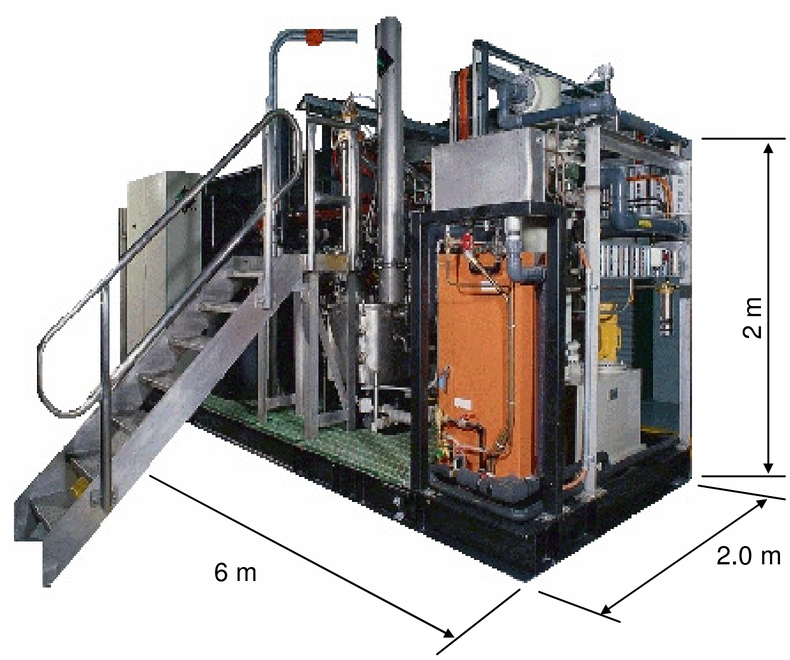

7. Wastes/Residuals:

7.1 Secondary waste stream volumes:

PLASCON facilities have two waste streams, namely a gaseous emission and an aqueous blow down from the scrubber system. The aqueous blow down is a slightly alkaline (pH of 8) stream comprising essentially sodium halide salts. As mentioned above POP concentrations are typically non detectable (<0.5µg/L). Typical blow down volumes are 0.5 to 1.2 kL/h. Gaseous emissions have flow in the order of 0.5 Nm^3/h and consist primarily of argon (79 % by weight), CO_2 (18.5 %), CO (2 %) and water (0.5%).

For the installations in Japan, it was reported that after the flare, total (PCDFs + PCDDs + Coplanar PCBs) emissions in the gas effluent are typically less than 0.01 ng-TEQ/Nm^3 (Japanese control level is less than 0.1 ng-TEQ/Nm^3) and CO concentration in the gas is less than 10 ppm. (Japanese control level of CO is less than 200 ppm) Total(PCDFs + PCDDs + Coplaner PCBs) emissions in the liquid effluent are typically less than 0.01 pg-TEQ/L. (Japanese control level is less than 10 pg-TEQ/L)***

7.2 Off gas treatment:

None after flare. See Table 1, 2 and 3 of Annex.

7.3 Complete elimination:

Yes. See Table 3 of Annex.

Detailed information and treatment examples:
In the separate Annex the following information is given:
Table 1: Technology overview - Summary - Technical Details
Table 2: Overview project experience per technology supplier
Table 3: Overview detailed project information per project - Project name (from Table 2)
Table 4: Client References for Plascon Plants in Australia

PART II: Criteria on the Adaptation of the Country to the Technology

Note: This part has to be filled in every time the "suitability" of the technology has to be examined for a certain country situation!!

A. Resource needs:

1. Power requirements :
PLASCON units are equipped with a standard 150 kW plasma torch for POPs. The plasma torch, water cooled reaction chamber (flight tube) quench and scrubbing system, power supply, associated pumps and process control system are mounted on the skid. This plant uses about 180 kW. In case of lack of electricity a 300KW generator would be sufficient for the Plascon and its ancillary equipment

2. Water requirements:
Cooling water and deionised water for cooling the torch (this stream is recycled through heat exchangers) Both cooling and deionised water are continuously reused but the plant used $1m^3/h$ of raw water for effluent discharge. Total water consumption with evaporation about $1.4m^3/h$. Incoming water does not need to be potable, but may need softening.

3. Fuel volumes:
No fuel is consumed

4. Reagents volumes:
Argon, oxygen and a 30 to 60 % caustic solution. Argon use is independent of throughput 15 m^3/hr
Caustic 1.4 ton / ton of concentrated waste (Caustic is directly proportional to waste concentration i.e. chlorine content)
Oxygen 0.8 ton/ ton of concentrated waste.(Oxygen use varies with chemical composition of waste and hydrocarbon solvents mixtures). The gasses and other chemicals used are fairly standard and readily available in locations where some industry is present - NaOH concentration is not critical, we have had plants operating on concentrations between 30% and 50%. Oxygen does not need to be particularly pure. Argon needs to be pure (<20ppm O2), but the welding argon in all localities that have investigated to date (including central and south America) is sufficiently pure.

5. Weather tight buildings:
Weather tight but ventilated.

6. Hazardous waste personnel requirement:
Personnel require training in the O H S aspects for each waste that is accepted for treatment.

7. Sampling requirements/facilities:
Sampling is required if the composition of the waste is not exactly known (unlabelled or open drums) it is also required to monitor effluent quality.

8. Peer sampling:
Independent sampling and analysis has been carried out by purchasers of plants during acceptance trials and commissioning.

9. Laboratory requirements:

On site requirements:
Below is the equipment listed, as used at one of the plants and any operator would need similar equipment, with the exception of the Mass Spectrometer is optional and depends on the waste treated:
2 Gas chromatographs fitted with Electro Capture Detectors (ECD) and auto samplers for liquids gas sampling Gas chromatograph fitted with 4 detectors including one ECD for your own gas sampling plus a Gaschromatograph fitted with a Mass Spectrometer Detector mainly used for identifying Pesticides.

Requirements in country:
Apart from compulsory in-house testing, Australian regulation requires retention of all records for 5 years including transport dockets.
Independent samples are collected 4 times per year at random and independently tested. The facility is audited once per year at short notice.

10. Communication systems:
The system is fully automated and is PLC controlled with a Citect SCADA system. Monitoring can be done by telephone or internet and from within by LAN.

Mobile network:

Fixed network:

11. Number of personnel required: 2

11.1 Number of Technicians required (skilled labour):1

11.2 Number of Labourers required (unskilledlabour):1

B. Costs: Standard 150KW PLASCON Plant approx. $USD 1.5 million. Operating & Maintenance Costs $USD 2.00 per Kg for Schedule Wastes

1. Installation and commissioning costs [US Dollars]:
Included in purchase price

2. Site preparation costs [US Dollars]:
$500 000

3. Energy & Telecom installation costs:
Depends on country

4. Monitoring costs:
Included in Operating costs

5. Complying costs:
Included in Operating costs

6. Reporting costs:
Included in Operating costs

7. Running costs with no waste:

8. running costs with waste:

9. Decommissioning costs:
Unknown.

10. Landfill costs:
Depending on local situation – Should be filled in for the concerned country

11. Transport costs of residues:
Depending on local situation – Should be filled in for the concerned country

C. Impact:

1. Discharges to air:

2. Discharges to water:
1m^3 /h containing 50 grams
Sodium chloride 5 gram sodium carbonate

3. Discharges to land:
None

4. Soil impact (noise etc):
Low noise

D. Risks: Several HAZOP's conducted on various plants showing few risks

1. Risks of reagents applied:
Caustic soda could be considered a reagent it is widely used in home and industry and well managed

2. Risks of technology:
The flare is provided as a separate fully engineered and controlled system. The system is fully automated and is PLC controlled with a Citect SCADA system.

3. Operational risks:
The plant is inherently safe since it is powered by electricity and can thus be shut down instantaneously. PLASCON units are equipped with all appropriate safety features and necessary containment measures so that the effects of any accidents are minimised.

E. Constructability:

1. Ease of installation/construction of plant:

2. Ease of shipping/transit:
The footprint of the skid is 12 m^2. The height is 2 m, so all fitting in containers.

3. Ease of operation:
Start up and shut down is completely automatic and operators can be trained in a short time.
Simple to operate. Easy to learn without special skills

4. Ease of processing:
The process is very robust and reliable, with up-times typically greater than 90%. Routine maintenance usually involves: weekly clean filters and feed nozzle. Monthly inspect torch and scrubber system.

F. Output/generation waste

1. Generated waste (% of input waste):
In addition the inventory of un-destroyed POPs in the system is very low at roughly 0.5 grams. The 0.5 gram is un-destroyed only in case of sudden shutdown and is the amount in the system at any given moment at a 45 kg/h feed rate. This 0.5 gram is recovered before a restart.

2. Deposited waste at landfill (% of input waste):
None

3. Waste quality properties (pH, TCLP):
PH 9 for rest see under discharge to water (C.2)

**Note: This Technology Specification and Data Sheet (TSDS) does not certify any particular technology, but tries to summarise the state of the art of the concerned technology on the basis of data delivered by the technology suppliers or other sources, which have been made available to the author and refers the reader to original documents for further evaluation. Without the efforts below listed technology suppliers it would not have been possible to set up this TSDS. Date:01.09.2008*

Technology suppliers that have contributed to this TSDS:

BCD Technologies Pty Ltd, Australia

Bridle Consulting, Australia

Mitsubishi Chemical Corporation, Japan***

SD Meyers de Mexico de CV

SRL Plasma Pty Ltd, Australia

References:

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