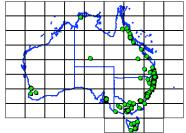
NATIONAL TOXICS NETWORK



NATIONAL TOXICS NETWORK INC.

Australian IPEN Focal Group International POPs Elimination Network PO Box 173 Bangalow 2479 NSW Australia ABN 61 118 160 280 Phone: (Int) 612 66871900 / 66815340 <u>http://www.oztoxics.org</u>

OBJECTION TO ORICA AUSTRALIA'S APPLICATION TO EXPORT TO GERMANY ITS STOCKPILE OF THE POPS WASTE, HEXACHLOROBENZENE AND ASSOCIATED MATERIAL FOR INCINERATION¹

National Toxics Network (NTN) is a NGO (non-government organisation) network working for pollution reduction, protection of environmental health and environmental justice for all. NTN is the Australian focal point for the International POPs Elimination Network (IPEN) working towards the full implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) 2001 and other relevant international and regional chemical treaties. NTN has a particular focus on children's environmental health and intergenerational equity.

Our Aim: to achieve successful, effective non-incineration destruction of HCB waste in Australia with community tolerance in a reasonable timeframe.

¹ NTN have been informed that this objection must be submitted to the Federal Minister for Environment and Heritage in a 'reasonable' time period after the application to export is gazetted (November 22, 2006). There is no clear-cut process for dealing with objections rather *the Hazardous Waste (Regulations of Exports and Imports) Act* 1989 (Cth) relies on notions of 'natural justice' for 'affected' people.

EXECUTIVE SUMMARY

The National Toxics Network (NTN) has actively participated over many years in the process to find a suitable option to clean up the contaminated Orica site at Botany NSW, which includes one of the world's largest stockpiles of hexachlorobenzene (HCB) waste.

In 1996 the Australian National Advisory Body (NAB) on Scheduled Waste released the National Management Plan for Hexachlorobenzene (HCB) to oversee the destruction of the HCB waste stockpile. The plan recommended that the waste should be destroyed as "close to the source as possible" in light of the risks in transporting such a large stockpile of hazardous waste and Australia's proven ability to destroy hazardous waste in an environmentally sound manner. The HCB Management Plan was endorsed by the Commonwealth Government.

NTN has consistently maintained that the stockpile of HCB waste must be destroyed in Australia by non-incineration technology that is acceptable to the community and within a reasonable timeframe. As a signatory to the *Basel Convention*, Australia has a moral responsibility to deal with its own hazardous waste.

Basel Export Permit application rejected

Orica Australia Pty Ltd (formally ICI Australia) under the *Hazardous Waste (Regulation of Exports and Imports) Act 1989* has lodged an application for a Basel export permit to transport 22,000 tonnes of hexachlorobenzene (HCB) waste to Germany for destruction via incineration.

NTN and other leading Australian and International organisations, including the German Green Party and civil society organisation BUND, are calling on the Australian Government to reject the permit application on the grounds that the claim for 'exceptional circumstances' under Section 18 (A) of the Act is unjustified because proven and environmentally safer technology is already available in Australia to destroy the waste.

Given that treatment technologies in Australia are available for the destruction of the HCB waste, any approval to export the HCB waste may be subject to legal challenge under Section 41 of the Act.

Responsibility for hazardous waste under the Basel Convention

Australia has a legacy of hazardous waste left behind by chemical corporations. For over two decades, Orica Australia Pty Ltd (formerly ICI Australia) produced a large quantity of hexachlorobenzene (HCB) waste as a byproduct from the manufacture of chemical solvents. HCB is one of the 12 chemicals listed in the *Stockholm Convention on Persistent Organic Pollutants 2001*.

Orica's permit application to export its HCB waste contravenes fundamental principles of environmentally sound management of hazardous waste as developed by the UN Secretariat of the *Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1989),* in particular:

- The self-sufficiency principle management and disposal of waste in the country where it was created;
- The proximity principle the disposal of hazardous waste as close as possible to their point of generation;
- The least trans-boundary movement principle trans-boundary movements of hazardous waste reduced to a minimum;

The Basel Convention under Article 4 also requires Australia to *"take the appropriate measures to …ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes."*

Orica's Hazardous Waste

Orica's HCB hazardous waste is currently stored at the Orica site in the Botany Industrial Park awaiting destruction. The site is surrounded by residential suburbs and sensitive ecosystems.

There are approximately 8,500 tonnes of drummed HCB waste and 1,000 tonnes of HCB waste held in storage tanks. There is also a range of other HCB contaminated materials, including sludges from effluent recovery pits, drains and storage tanks. Another 45,000 cubic meters of soil, contaminated sand and coal ash is "encapsulated" on site and often referred to as the 'car park waste'.

The hazardous waste is made up primarily of halogenated aromatic hydrocarbons such as hexachlorobenzene (HCB), hexachlorobutadiene (HCBD) and, hexachloroethane (HCE). These compounds do not occur naturally and are highly persistent in the environmental due to their chemical stability and resistance to biodegradation.

The short-term health effects of high exposures to HCB can lead to kidney and liver damage, central nervous system excitation and seizures, circulatory collapse, and respiratory depression while long-term low exposures may damage a developing fetus, cause cancer, lead to kidney and liver damage and fatigue. HCB has been detected in breast milk and the International Agency for Research on Cancer classified HCB as a Group 2B carcinogen.

Where the waste would go in Germany

The intended destination of the HCB waste is four incinerators in Germany. The destination port in Germany has been identified at Brunsbuttel near the mouth of the River Elbe.

Two of the incinerators are operated by Bayer and are located in industrial parks in Dormagen and Leverkusen, which are approximately 250km from the nearest port access at Brunsbuttel. Orica has incorrectly indicated that the two facilities are located in Bavaria. These two towns are actually located in North Rhine-Westphalia (Nordrhein-Westfalen). Orica intends to transport the waste to the Bayer facility by a rail link which runs from the port to both of the industrial parks.

Risks of exporting the HCB waste

A number of significant risks are associated with the application to export 22,000 tonnes of HCB waste to Germany for incineration, with a possible transit via South Africa for bunkering purposes. The risks are associated with both the *transport* and *treatment* of the waste.

Orica estimate that four shipments will be required depending on the ability of the incinerators to burn the waste and the rate at which the repackaging plant will operate in Botany. The transport of the waste will take around 21 months.

Transport risks

- Contaminated spills, dust release and fugitive emissions during the excavation and packaging of the waste and repackaging of stockpiled waste for transit;
- Transport accidents when transporting hundreds of drums of HCB waste to the departure port in Australia;
- Spills, accident or loss of entire containers at sea with potentially long- term irreversible pollution damage to marine ecosystems due to the long persistence and toxicity of HCB in the environment. Worst case scenario being the loss of a HCB loaded vessel in heavy seas;
- Spills and or other incidents at transit port (potentially South Africa) with potentially long-term irreversible damage to inshore aquatic ecosystems;
- Spills and or other incidents at destination port at the mouth of the river Elbe in Northern Germany with potentially long-term irreversible damage to inshore aquatic ecosystems and river biota;
- Transport accident in Germany during the transfer of the HCB waste to the SAVA incinerator in Brunsbuttel, the Bayer incinerators and landfill in Dormagen and Leverkusen or the RZR Herten incinerator in Nordrhein-Westfalen. Significantly higher risks apply to the transport of HCB waste to the RZR Herten facility which will be over 200km by public roads;

Incinerator Treatment risks

Incineration of HCB's does not ensure their full destruction and almost certainly leads to the generation of many harmful compounds that can escape into the atmosphere. Incineration is considered by researchers as a poor method by which to attempt to destroy HCB waste.

The *Stockholm Convention* lists incineration of hazardous waste as a priority source of releases of dioxins and furans. Dioxins and furans are among the most toxic of all compounds ever studied and will be released to atmosphere as a part of the incineration of Orica's HCB waste in Germany.

Compared to non-combustion technologies, incinerators have poor Destruction Efficiencies (DE). The primary reason is that while incinerators have become better at removing pollutants from the stack gases by various scrubbers, the pollutants still have not been destroyed, rather they are transferred to another media such as fly ash, filter cake, scrubber liquors or bottom ash. Dioxins will remain in the unwanted ash by-products and have the potential to pollute the German, European and global environment. Large quantities of contaminated 'bottom ash' will be produced which is currently disposed of under European roads and in concrete products while the highly toxic 'flyash' is sent for permanent storage to German salt mines.

A recent report by the International POPs Elimination Network (IPEN) demonstrates major problems with the unregulated and partially regulated use of incinerator ash in Europe as a construction material. In the Netherlands, fly ash is a major route for dioxin releases from waste incineration to the environment

Australian technology can effectively destroy the HCB waste

Australian waste treatment companies have already demonstrated the capability to treat POPs waste such as HCB to a high level of Destruction Efficiency (DE) without incineration. In the past decade, the Eco Logic Gas Phase Chemical Reduction process in Kwinana, WA, destroyed Australia's major stockpile of PCB's. That technology is no longer available in Australia but has been replaced by other suitable technologies.

More recently Australia reached agreement with Pacific Island nations to bring back POPs including PCB's that had primarily originated from Australia in the past. These POPs wastes were successfully treated by the hazardous waste facility at BCD Technology Pty Ltd at Narangba in Queensland.

The two processes currently capable of treating the HCB waste in Australia are;

- Base Catalyst Dechlorination (BCD)
- Plasma Arc destruction (Plascon)

These technologies have proved successful overseas in effectively destroying hazardous wastes. Orica is aware of both these technologies and their availability in Australia. There is documentation to support destruction efficiencies of 99.9999% for chlorinated compounds such as HCBs.

Conclusion

The proposal by Orica to export highly toxic HCB waste to Germany for incineration is unjustified and should be rejected. Suitable destruction technologies already exist in Australia that can destroy the HCB waste in a way that achieves a far better environmental outcome than incineration in Germany. Treatment in Australia also avoids most of the risks associated with transport of the waste across the globe and through Germany.

NTN urges the Australian Government to consider this controversial proposal carefully, and to fully examine the available options for domestic treatment. Any reasonable assessment of Orica's HCB export proposal must lead to its rejection.

SECTION 1 WHY IS NTN INVOLVED?

NTN has been involved for many years in the campaign to clean up the Orica site in the Sydney suburb of Botany, which includes one of the world's largest stockpiles (14-22,000 tonnes) of hexachlorobenzene (HCB) waste. NTN has maintained that the stockpile must be destroyed by non-incineration technology that is acceptable to local communities and the Australian people.

NTN considers that the current proposal by Orica to export the waste by ship to Germany for incineration is in contravention of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes & their Disposal (1989) and the Australian Hazardous Waste Act *as technologies are available in Australia which can treat the HCB waste adequately.* Therefore no 'exceptional circumstances' under Section 18A of the Hazardous Waste Act apply requiring the export of the HCB waste to Germany.

NTN is not alone in this view and this formal objection to the HCB export represents the views of many Non Government Organisations (NGOs) including NTN members groups, participating organisations of the International POPs Elimination Network (IPEN) members, international NGOs and many German environment and civil society organisations.

As Australia's peak NGO dealing with toxics and pollution issues, NTN has maintained a keen interest in the HCB controversy over many years. Senior members of NTN have been involved in a number of bodies dealing directly and indirectly with HCB waste including the:

- National Advisory Body on Scheduled Waste (NAB)
- NAB HCB Consultation Panel
- Hazardous Waste Policy Reference Group
- Dioxin Consultative Group
- Stockholm Reference Group
- NTN Observer on Hazardous Waste Technical Group
- NTN Observer on the Botany Community Participation and Review Committee (CPRC)

Supporters of this Objection

The following organisations have indicated their strong objection to either the export of Orica's HCB waste from Australia and its incineration in another country (in this case Germany).

In Australia:

- Australian Conservation Foundation
- National Toxics Network
- Greenpeace Australia Pacific
- Australian GREENS
- NSW GREENS
- Conservation Council of Western Australia
- Total Environment Centre
- Friends of the Earth Australia
- Nature Conservation Council NSW

In Germany:

- The BUND (Environment and Nature Protection Community Germany) the biggest environment and nature protection community in Germany with more than 400,000 registered members.
- Bayer Danger Coalition
- Women in Europe for a Common Future, Germany WECF e.V.
- The German GREENS
- KITE (European Anti-Incineration Network)

International Organisations

- International POPs Elimination Network (IPEN
 - 400 IPEN Participating organisations (POs)
 - Dioxin and PCB Working Group
- Basel Action Network
- Global Anti Incineration Alliance (GAIA)²

Affected Communities in Germany

Despite the claims that there is no opposition to the incineration of Australian hazardous waste, there is clear evidence of a growing number of German environment and public interest organisations who oppose the import of Australian hazardous waste into their country. These include some of the biggest German NGOs, eg., The BUND (Environment and Nature Protection Community Germany) - the biggest environment and nature protection community in Germany with more than 400,000 registered members, as well as many smaller local and regional groups directly affected by the import. In the second week of January 2007, one of the journals with the highest distribution (circulation more than 500.000) in the Ruhr area where one of the 4 incinerators is located reported the proposed import of Australian toxic waste on the first page and with editorial comment titled "It stinks".

The District councils are the administrative units outside the big cities in Germany, bundling smaller cities and rural communities. In one district council is the city of

² In 2005, 120 participating organizations of GAIA wrote a combined letter to Minister Campbell expressing their clear opposition to the export of the HCB waste for incineration.

Herten, where the RZR Herten waste burning plant is situated, the final destination for 5,000 tons of Orica's waste. The incinerator is owned by a federation of cities in the metropolitan area of The Ruhr (100 kilometers in the North of Cologne. Local Council members report that its officials, among them many politicians, often claim that it is one the most modern refuse incinerators in the world with a multiple fuel gas cleaning installation, but the issue is very controversial.

The Parliamentary group for the District Council of Recklinghausen have reported that even though there are comparatively high emission rules for waste gas, that is, less than 0.1 ng/mÂ_ of combined dioxin and furans, the Herten incinerator is a heavy load for the environment. The plan to burn 5,000 tons of Australian waste containing HCB has left many residents now feeling insecure. The area is densely populated, there are some 0 million people living around in the 100 kilometre reach. The emission record on the internet homepage of the company running the Herten RZR incinerator is reported to be regularly down with the community unable to source emission data from last year.

Environmental and chemical experts from the BUND have identified unacceptable low incineration temperature of 900°C in the Herten RZR incinerator which is "less than the 1100°C, required by the waste incineration directive for HWI of hazardous waste with more than 1 weight-% of organic chlorine." They have also reported that the amount of chlorine would be doubled by the Australian toxic waste; added to the load already contracted, the prescriptive limit values for chlorine input would be well exceeded.

The BUND Federal Waste Management Working Group reports that there is already a lot of resistance to the proposed incineration in Herten. In the case of the RZR Herten HCB incineration proposal, BUND has launched an environment information request to the permission authority, the Regional Government Münster for information on the import notification permission and the permission for incineration of the HCB waste.

They report that despite of the claims of the RZR operator company (press speaker Mr. Struszczynski), there is not yet an incineration permit for the HCB waste and in addition there is no import notification permission given as yet which was confirmed by the press speaker of the Regional Gouvernment Münster. In response to their additional requests for information at the Federal Environment Office (UBA) BUND was informed that nothing was known.

However, BUND also report that company representatives are claiming they will receive the Australian HCB export notification permission within two weeks. The company has announced that the incineration is proposed to start on May, 2007 in the RZR Herten facility.

The Green Party Northrhine-Westphalia has also launched a request in the Country Parliament Northrhine-Westphalia and a time has been designated on January 17th in the parliament to discuss the topic "*Is the incineration of Australian hazwaste in the RZR Herten really permittable?*." There is also public meeting and podium discussion proposed for Herten on February 6th to discuss the Australian HCB hazardous waste.

Yet, not only are environmentalists in Germany critical of the import of the Orica waste, several newspaper articles about the planned hazardous waste deal have been published. One of the journals, the Westdeutsche Allgemeine Zeitung, with the highest distribution (circulation more than 500,000) in the Ruhr area where one of the incinerators destined to burn HCB waste is situated, reported on the Australian toxic waste on the first page and an editorial comment titled *"It stinks"*.

The UWG (free voters community, member in the Herten City Parliament) and the Green Party in the city of Herten have given critical comments which were published in the newspaper "Westfälische Rundschau" on January 10th.

It is evident that there is strong opposition to the import of Australian waste in German communities.

Orica is quoted in the media as saying, "where there is opposition we will not go" (Environmental Manager, No 547, 11 July 2006).

SECTION 2. BACKGROUND AND IMPACTS OF HEXACHLOROBENZENE

2.1 History of Hexachlorobenzene

Hexachlorobenzene (HCB) came to notoriety in Turkey in the 1950s when wheat intended for planting and treated with fungicide, HCB, was ground into flour and made into bread. More than 600 cases of poisoning were reported, many of whom were children. Mothers who had eaten the HCB-contaminated bread gave birth to babies with a disorder called pembe yara (*"pink sore"*). At least 95%, of these children died before they were 12 months old. In the 20-30 year follow-ups of exposed people, neurological, dermatological and orthopaedic abnormalities were still evident.

As well as its use as an agricultural chemical, internationally, HCB has been used in the manufacture of pyrotechnics, tracer bullets and as a fluxing agent in the manufacture of aluminum and in the production of rubber. HCB was also used until recently as a wood preserving agent and in tanning of hides.

Argentina was the first country to act on the growing evidence of the adverse impacts of HCB and in 1963, prohibited it as an insecticide for sheep in certain parts of the country. In 1968 Hungary moved to ban all pesticides containing HCB due to experimental data showing residues in the fatty tissue of humans and animals. HCB was subsequently withdrawn across Europe and finally banned in 1978 under a Council Directive (79/117/EEC).

By the mid 1980s, a range of studies³ had found HCB in breast milk including Australian studies.⁴ In 1986, the International Agency for Research on Cancer classified HCB as a Group 2B carcinogen, that is, it could possibly cause cancer in humans, based on evidence of its carcinogenicity to animals.⁵

By the late 1980s, the European Community moved to control (EC Directive 88/847/) the discharge of dangerous substances like HCB and a number of other countries followed their lead. By June 1988, Canada labelled HCB as 'toxic' under its *Canadian Environmental Protection Act*, and listed it as a "non-threshold toxicant" constituting a danger to the environment and to human life and health.

In 2001, HCB was included in the 12 original substances listed for eventual elimination in the *Stockholm Convention on Persistent Organic Pollutants* 2001 In Australia HCB waste is considered a 'scheduled waste' because it is organic in nature, (i.e., it's based on carbon molecules); resistant to degradation (breakdown) by chemical, physical or biological means; toxic to humans, vegetation or aquatic life, and bioaccumulates in humans, flora and fauna.

2.2 Health and Environmental Impacts of HCB

HCB is a highly persistent environmental toxin due to its chemical stability and resistance to biodegradation. Environmental levels peaked in the 1970s and have generally declined since that time, primarily due to the cancellation of HCB as a registered pesticide.

HCB is toxic by all routes of exposure. Studies in animals have shown that chronic exposure to HCB can damage the liver, thyroid, nervous system, bones, kidneys, blood, and immune and endocrine systems. The immune systems of rats that breathed HCB for a few weeks were harmed and the U.S. Department of Health and Human Services (DHHS) has determined that HCB may reasonably be expected to be a carcinogen. The International Agency for Research on Cancer (IARC) considers HCB a possible human carcinogen.⁶

Short-term high exposures can lead to kidney and liver damage, central nervous system excitation and seizures, circulatory collapse, and respiratory depression while long-term low exposures may damage a developing fetus, cause cancer, lead to kidney damage, liver damage, and fatigue, and cause skin irritation.⁷

⁵ IARC, 1986 Hexachlorobenzene: Proceedings of an International Symposium, IARC publications No 77

³ For example see; M. Ando, S. Hirano, and Y. Ito, "Transfer of HCB from mother to new-born baby through placenta and milk", *Arch. Toxicol. 56*, *1985*, *196-200*.

⁴ "Herbicides & Pesticides in Human Breast Milk: A Comparative Study of rural & Urban Mothers Milk in NSW" Paul E Spicer Masters of Public Health, University of Sydney 1986

⁶ International Agency for Research into Cancer, *IARC 1986 Hexachlorobenzene*, IARC publications No 77, 1986. Also see UNEP Chemicals, Regional Reports of the Regionally Based Assessment of Persistent Toxic Substances Program (2002) Available from: http://www.chem.unep.ch/pts UNEP Chemicals

[†] United States Environment Protection Agency, US EPA Fact-Sheets 1A Hexachlorobenzene CAS Number 118-74-1 DOT Number: UN 2729 (January 1989)

HCB is detected throughout the environment and is regularly found in blood, breast milk and fats of humans and wildlife.

People are exposed to HCB through eating low levels in contaminated food such as contaminated fish, milk or dairy products or meat from cattle grazing on contaminated pastures. People can also be exposed through drinking contaminated water or by breathing low levels in contaminated air, eating or touching contaminated soil or working at a factory that uses or produces HCB unintentionally. Drinking contaminated breast milk from exposed mothers is a significant source of HCB for babies.

HCB contamination comes from diverse sources such as industrial emissions and HCB based agricultural chemicals (now banned). HCB does not dissolve in water so most remains in particles on the bottom of lakes and rivers allowing high levels to build up in fish, marine mammals and birds. It also adheres strongly to soil and can accumulate in wheat, grasses, some vegetables and plants.

As HCB breaks down very slowly, remaining in the environment for a long time and is dispersed across the globe by both air and water, the international community included HCB on their target list of persistent organic pollutants or POPs.

2.3 The Origins of HCB waste at Botany

For over two decades, the chemical company, Orica Australia Pty Ltd (formerly ICI Australia) produced a large quantity of hexachlorobenzene (HCB) waste. This industrial waste was an unwanted byproduct from the manufacture of chemical solvents and was never used by Orica for commercial purposes. Approximately 14,000-22,000 tonnes of HCB waste is now stored at the Orica site in the Botany Industrial Park in Sydney NSW awaiting destruction. The site is surrounded by residential suburbs.

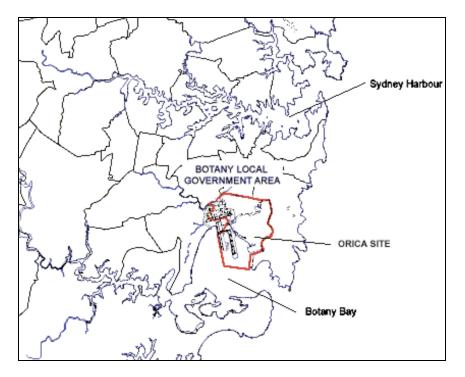


Figure 1 Orica site at Botany

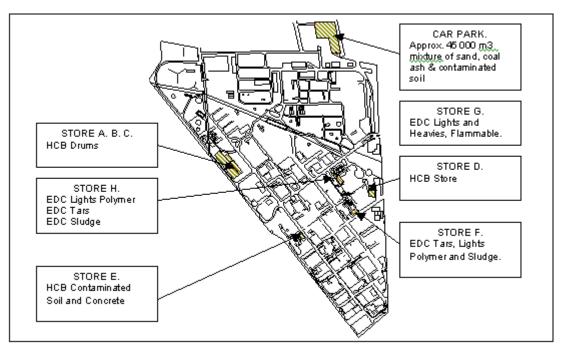


Figure 2 Waste storage at the Botany site.

2.3.1 Manufacture of Chlorinated Solvents

The chlorinated solvents, carbon tetrachloride and perchlorethylene were manufactured at Botany from 1964 to 1991. This involved the reaction of propylene with chlorine, which produced both the desired commercial products for drycleaning fluids as well as a range of unwanted organochlorine chemical residues.

These residues were called the "heavy ends". From 1964 until 1977, the heavy ends were placed into drums and stored. In 1977 the Heavy Ends Treatment Plant was commissioned to reduce the amount of waste needing long-term storage. This was done by first crystallising and then separating hexachlorobenzene (HCB) from the liquid heavy end components principally hexachlorobutadiene (HCBD) and hexachloroethane (HCE) The HCB crystals were then stored in drums while the HCBD and HCE were recycled back into the solvents process.

The drummed HCB waste from chlorinated solvent manufacture makes up a major component of the HCB waste at Botany.

2.3.2 Manufacture of Ethylene Dichloride

The chemical, ethylene dichloride or EDC is manufactured as a precursor to the vinyl chloride monomer (VCM), which is used in the production of polyvinyl chloride or PVC. The manufacture of EDC also produces unwanted by-products in the form of organochlorine chemicals, containing low levels of HCB. Prior to 1991, most of these residues were recycled to the Solvents Plant. In 1991, a dedicated by-products recycling process was added to the VCM Plant. Although no further EDC residues have been produced since the commissioning of the recycling plant, there remains a range of wastes that were unable to be recycled prior to closure of the Solvents Plant. Some of the stored waste had partially 'polymerised' preventing recycling.

The Solvents Plant that originally generated the HCB waste was demolished but this generated an additional 300 tonnes of low level scheduled HCB waste. This material is in secure storage on site.

2.4 The HCB Waste Types

There is approximately 8,500 tonnes of HCB waste stored in 55,000 x 200 litre steel drums on wooden, non-reusable pallets. The majority of the drums are polythene lined, labeled and identifiable by category. Some drum corrosion occurs over time, which means inspection and re-drumming programs are carried out to ensure the integrity and safety of the stored waste.



Figure 3 High concentration HCB waste



Figure 4 Polymerised HCB waste

There is approximately 1,000 tonnes of HCB Waste from the manufacture of ethylene dichloride. This material comprises solvent laden low-grade polymers that have settled and partially polymerised during extended storage in concrete tanks. The material is 70-80% w/w solvent and 20-30% w/w solid. The majority of this material is held in 25 m3 storage tanks on the Botany site. Some has been stored in 200 litre drums.

There is also a range of other HCB contaminated materials, including settled sludges from effluent recovery pits, drains and storage tanks, Evaporator Residues (char), carbon slurry removed from vessels and distillation columns on the plant, sand, rust and iron (iron oxides, ferric chloride) from drum corrosion and polyethylene from polyethylene bags and liners. Other items include protective gloves, carbon adsorbent and packing, rags, safety boots and respirator canisters.

Approximately another 45,000 cubic metres of soil, contaminated sand and coal ash is "encapsulated" on site and is often referred to as the 'car park waste'. This HCB Waste is primarily soil contaminated with HCB due to leakage from corroding drums stored on soil without proper bunding prior to 1978. Prior to the construction of a new processing plant on the original storage site, all the contaminated soil was excavated. This material

was encapsulated in a Hypalon⁸ membrane, mounded with clean soil then capped with bitumen with a drainage diversion and monitoring system installed.

2.5 Components of the HCB Waste

The waste is made up primarily of the chemicals, hexachlorobenzene (HCB), hexachlorobutadiene or HCBD and hexachloroethane or HCE. These belong to a class of chemicals called halogenated aromatic hydrocarbons. These compounds do not occur naturally. While HCB has no current commercial uses, HCBD is used to make rubber compounds and is used as a solvent, and to make lubricants. HCE is used by the military for smoke-producing devices. All three are also formed as unwanted byproducts of various manufacturing processes, waste streams, and combustion operations. They can also be found as a trace impurity in some currently used pesticides, chlorinated solvents, and other chlorinated compounds.

HCB is the major component of the drummed waste. It is present mostly as powder (crystals) and is free-flowing but can also be lumpy solid mixtures and sticky. The HCB content averages about 53%, Hexachloroethane (HCE) about 15% and Hexachlorobutadiene (HCBD) about 27%, but there is a large variation between the individual drums of waste. Within each drum, the composition can vary widely, from hard lumps of nearly pure HCB to a wet slurry of primarily HCE. The slurries saturated with HCE are thicker and more difficult to pump.



Figure 5 Orica HCB waste as a rubbery compound

The "heavy ends" are lumpy solid materials, higher in HCE and lower in HCB. Some have cast solid in the drum. HCBD is the liquid component of the heavy ends and makes HCB crystals sticky, and has the highest vapour pressure of the components of the HCB Waste.

⁸ A Hypalon membrane is a plastic liner designed to last a long time and fully encapsulates contaminated soil as an envelope. Unfortunately, there is now some evidence that the membrane has been breached.

Other chemicals present include:

- Octachlorostyrene, OCS
- Carbon Tetrachloride, CTC
- Perchlorethylene, PCE

SECTION 3. AUSTRALIA'S OBLIGATION TO MANAGE ITS WASTE

Australia has a moral obligation to deal with its own waste and should not shift its responsibilities for hazardous waste off-shore.

3.1 International Obligations

Orica's current proposal to export its HCB waste contravenes the principles of environmentally sound management of hazardous waste as developed by the UN Secretariat of the *Basel Convention on the Control of Transboundary Movements of Hazardous Wastes & their Disposal* (1989).

These principles include:

f) the self-sufficiency principle - management and disposal of waste in the country where it was created.

g) the proximity principle - the disposal of hazardous waste as close as possible to their point of generation.

h) the least trans-boundary movement principle – trans-boundary movements of hazardous waste reduced to a minimum.

The Basel Convention under Article 4 also requires Australia to "take the appropriate measures to (b) Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes."

3.2 National Obligations

In 1996 the Australian National Advisory Body (NAB) on Scheduled Waste released the National Management Plan for Hexachlorobenzene (HCB)⁹ to oversee the destruction of

⁹ Available at http://www.oztoxics.org/hcb

the HCB waste stockpile. The plan recommended that the waste should be destroyed as "close to the source as possible" in the light of the risk in transporting such a large stockpile of persistent organic pollutant (POPs) waste and Australia's proven ability to destroy hazardous waste in an environmentally sound manner. The HCB Management Plan was endorsed by the Federal Australian Government and NSW State Government.

One of Orica's key arguments for exporting the waste is that they have failed to locate technology in Australia that can successfully destroy the HCB waste at its current site in Botany, New South Wales or at more remote locations in NSW due to lack of community acceptance and stakeholder support. However, there is evidence that suggests that stakeholders will support the destruction of the HCB waste in Australia if Orica adopts a proven non-incineration technology, and that destruction is preferably not at the Botany site which is now surrounded by high density residential areas.

NTN has been made aware that successful destruction trials of HCB have been undertaken in Australia with existing technology and that some modification of existing non-incineration technologies coupled with a two-stage approach to prepare the waste for treatment, would provide a destruction option for the HCB waste within Australia.¹⁰ Numerous misleading claims have been made about the lack of technical capacity for HCB treatment in Australia despite documentation to the contrary. The technology options available in Australia are described in Section 4.

SECTION 4. DANGER IN TRANSPORT AND RISKS IN INCINERATION

4.1 Transport Dangers

For at least a decade the Australian Government has been aware of the risks and danger associated with transport of hazardous waste over long distances, particularly with regard to the marine environment where the consequences of spills and cargo loss may lead to irreversible, long-term environmental harm.

As the statutory Management Plan for HCB is still operational NTN believes the Commonwealth Government and Orica have an obligation to thoroughly investigate and exhaust all Australian options for treatment of the HCB waste before setting in train a range of high level risks for the environment and human health by shipping the waste to Germany. This is especially the case as the technology is available in Australia for the treatment of HCB waste which can provide better environmental outcomes than those that can be achieved in Germany through incineration.

The NTN has identified a number of key risks associated with the application by Orica to export 22,000 tonnes of HCB waste to Germany for incineration transiting via South Africa for bunkering purposes. Orica estimate that four shipments will be required depending on the ability of the incinerators to burn the waste and the rate at which the

¹⁰ Correspondence - DoloMatrix Australia Ltd to Orica, 5 Sept 2006

repackaging plant will operate in Botany. Orica estimate the transport of the waste will take around 21 months.

The risks are divided into two main categories:

- 1. Transport
- 2. Treatment

The most significant transport related risks include:

- Short-term risk of contaminated spills, dust release and fugitive emissions during the packaging of and repackaging of stockpiled waste for transit in Australia.¹¹
- Short-term risk of transport accident when transporting thousands of drums of HCB waste to the departure port in Australia.
- Short-term risk of spills, accident or loss of entire containers at sea with potentially long- term irreversible pollution damage to marine ecosystems due to the long persistence and toxicity of HCB in the environment. Worst case scenario being the loss of a HCB loaded vessel at in heavy seas.
- Risk of spills and or other incidents at transit port (potentially South Africa) with potentially long-term irreversible damage to inshore aquatic ecosystems.
- Risk of spills and or other incidents at destination port at the mouth of the river Elbe in Northern Germany with potentially long-term irreversible damage to inshore aquatic ecosystems and river biota.
- Short-term risk of transport accident in Germany during the transfer of the HCB waste to the SAVA incinerator in Brunsbuttel, the Bayer incinerators and landfill in Dormagen and Leverkusen or the RZR Herten incinerator in Nordrhein-Westfalen. Significantly higher risks apply to the transport of HCB waste to the RZR Herten facility which will be over 200km by public roads.
- Risk associated with the transport of highly toxic ash to Heilbron.

While Orica have provided only limited information about the transit routes for the HCB waste, NTN understands that the waste will be shipped in 3-4 dedicated container ships from Australia to Germany, possibly transiting via a South African port.

The intended destination of the HCB waste is four incinerators in Germany. The destination port in Germany has been identified at Brunsbuttel near the mouth of the River Elbe. Two of the incinerators are operated by Bayer and are located in industrial parks in Dormagen and Leverkusen which are approximately 250km from the nearest port access at Brunsbuttel. Orica has incorrectly indicated that the two facilities are located in Bavaria. These two towns are actually located in North Rhine-Westphalia (Nordrhein-Westfalen). Orica intends to transport the waste to the Bayer facility by a rail link which runs from the port to both of the industrial parks.

¹¹ If as we have been informed, the car park waste may be also considered for treatment and export then there are short-term risk of contaminated dust release and volatilization of HCB to ambient air from soil matrices during excavation, pre-treatment and packaging of the 'carpark waste' cell.



Figure 6 Port of Brunsbuttel on the River Elbe

The SAVA Brunsbuttel Sonderabfallverbern-nungsanlagen GmbH incinerator is located near the port of Brunsbuttel at the mouth of the River Elbe and will burn the highest concentration waste. The SAVA incinerator is run by REMONDIS Industrie Service GmbH, Lunen. The RZR Herten incinerator is located around 20 km north east of Essen in North Rhine Westphalia. The RZR Herten incinerator dumps its toxic ash residues in a salt mine 300 km away in Heilbronn (40 km north of Stuttgart).

A Netherlands company, AVR Industries NV will arrange the logistics of the HCB waste transport for Orica from Australia to Germany.

The key risks are clearly associated with sea transport of thousands of kilometres followed by hundred of kilometres of rail or road transport within Germany. Only the SAVA incinerator appears to have any direct port access which might reduce the transport risks to some degree. This facility has a private road from the port along which the HCB waste will be transported. The only detail of the proposed transit modes within Germany are listed in the table below.

TREATMENT FACILITY	PRIMARY TRANSPORT ROUTE	ALTERNATIVE TRANSPORT ROUTE
AGR Herten	 by rail from Brunsbüttel to Leverkusen by road from Leverkusen to Herten 	 by rail from Brunsbüttel to Wanne-Eickel by road from Wanne-Eickel to Herten
Bayer Dormagen	 by rail from Brunsbüttel to Leverkusen by road from Leverkusen to Dormhagen 	 by rail from Brunsbüttel to Köln-Eifeltor by road from Köln-Eifeltor to Dormagen
Bayer Leverkusen	 by rail from Brunsbüttel to Leverkusen by road from Leverkusen to Leverkusen 	 by rail from Brunsbüttel to Köln-Eifeltor by road from Köln-Eifeltor to Leverkusen
Sava Brunsbüttel	• by private road from Brunsbüttel port.	N/A

4.2 Treatment Dangers

The second category of risk arises from the proposed treatment (disposal) of the HCB wastes via incineration. The risks are significant, long-term in nature and have the potential to negatively impact upon human health and the environment in Germany.

The transfer of the risks associated with HCB treatment from Australia to the German people and their environment is a morally reprehensible proposal which NTN will continue to oppose and highlight to the Commonwealth Government and citizens of Germany Australia and South Africa.

Details of the risks and hazards generated by the incineration of POPs waste, including HCB, are detailed in the following section.

SECTION 5. THE CASE AGAINST INCINERATION

5.1 Incineration and Disposal of Waste Byproducts in Germany

The *Stockholm Convention on Persistent Organic Pollutants* 2001 lists incineration of hazardous waste as a priority source of releases of dioxins and furans.¹² The higher the chlorine content of the waste materials burned, the greater the quantity of dioxins formed. Dioxins and furans are among the most toxic of all compounds ever studied and will be released to atmosphere as a part of the incineration of Orica's HCB waste in Germany.

NTN considers that current incineration practices are unsustainable. Dioxins are either released via air, or remain in the unwanted ash byproducts and have the potential to pollute the German, European and global environment. Large quantities of 'bottom ash' are currently used under European roads and in concrete products while highly toxic 'flyash' is sent for permanent storage to German salt mines. Karolina Sulova of the Czech Republic Environment Ministry recently rejected German imported waste for incineration stating:

"The remnants after the incineration always make up about one-third of the original quantity. They have hazardous qualities and must be stored at an appropriate dump,"

TheCzech Environment Ministry has been locked in a court dispute with the Munichbased company since 2004 when the company asked for permission to bring 6,000 tonnes of waste to the Termizo incinerator in Liberec.

In the early 1990s, the regulatory dioxin standard of 0.1 nanogram/metre³ was officially adopted for air emissions from German incinerators. Technologies based on activated carbon filters made it possible for the proprietors to keep within the limits of the 0.1 ng/m³ TE standard when pre-arranged inspections are carried out. The introduction of this limit led to major increases in PCDD/PCDF in incinerator ash.

5.2 Inadequate monitoring for hazardous waste incinerators

The 0.1 ng/ m_N^3 WHO- TEQ regulatory limit assumes that a number of parameters have been met prior to or during sampling of stack gases. These include representative waste being burnt at the time of sampling, steady state operation of the incinerator and sampling techniques that accurately capture concentrations of PCDD/PCDF in post combustion flue gas.

¹² Stockholm Convention on Persistent Organic Pollutants 2001 Annex C UNINTENTIONAL PRODUCTION Part II: Source categories. Polychlorinated dibenzo-p-dioxins and dibenzofurans, hexachlorobenzene and polychlorinated biphenyls are unintentionally formed and released from thermal processes involving organic matter and chlorine as a result of incomplete combustion or chemical reactions. The following industrial source categories have the potential for comparatively high formation and release of these chemicals to the environment: (a) Waste incinerators, including coincinerators of municipal, hazardous or medical waste or of sewage sludge;

Sampling in European nations is usually conducted periodically (quarterly or annually) using the EN 1948 dioxin sampling method. This involves capture of a sample over a 6 hour period usually conducted while the incinerator is carefully operated in a steady state.

In 1993, concerns over lack of correlation between elevated PCDD/PCDF soil concentrations and stack emission concentrations around a waste incinerator in Belgium led to a broader study of the accuracy of the EN 1948 point sampling method and whether it produced representative results of long-term operating emissions. The study compared the results of PCDD/PCDF sampling using the EN 1948 method and the 'Arnesa' air monitoring system which was used for continuous sampling periods of 15 days. The results indicated that the standard measurement underestimated dioxin emissions by a factor of 30 to 50.¹³

Destruction facilities to be considered for the Orica HCB stockpile must, at a minimum, be able to demonstrate that they can maintain dioxin emissions within the 0.1 ng/ m_N^3 WHO- TEQ regulatory limit using the continuous Arnesa system.

The sampling of incinerator flue gases for PCDD/PCDF analysis is almost universally conducted during steady state operation at optimum temperatures for dioxin suppression. It has been known for some time that incinerator plants produce higher levels of dioxin and dioxin-like emissions during upset conditions and during start-up phases¹⁴.

Temperature fluctuations during start-up and operation can also lead to 'scrubber bypass' situations unless prohibited by statutory mechanisms. If gas temperatures in the incinerator are too high baghouse fabric filters can be damaged causing elevated emissions. In some facilities the flue gases are switched to bypass mode to prevent baghouse fabric damage until normal temperatures can be reached. In this case untreated or partially treated flue gases are released to atmosphere with high concentrations of contaminants. Conversely, low temperatures can cause collation or clogging of lime injection mechanisms increasing emission concentrations.

A recent (2006) paper¹⁵ examining PCDD/PCDF emissions for a Japanese incinerator during both start up and steady state operations concluded that the incinerator clearly met the 0.1 ng/Nm³ WHO-TEQ regulatory limit while operating in steady state conditions but exceeded the regulatory limit 19 fold at the stack exit during start up conditions. Of particular interest is the comparison between boiler and stack exit concentrations. The average concentration of the dioxins at startup (RUN1-RUN5) was 18 ng WHO-TEQ/m³_N at the boiler outlet, and 1.9 ng WHO-TEQ/m³_N at the stack.

¹³ De Fre R., and Wevers M., 1998 Underestimation in dioxin emission inventories. *Organohalogen Compounds* Vol 36 1998

¹⁴ Takasuga et al., 2004. Formation of Polychlorinated Naphthalenes, Dibenzo-*p*- Dioxins, Dibenzofurans, Biphenyls, and Organochlorine Pesticides in Thermal Processes and Their Occurrence in Ambient Air. *Archives Environ. Contam. Toxicol.* Vol 46 : 419-431

¹⁵ Hajime Tejima, Masahide Nishigaki, Yasuyuki Fujita, Akihiro Matsumoto, Nobuo Takeda and Masaki Takaoka 2007 Characteristics of dioxin emissions at startup and shutdown of MSW incinerators. *Chemosphere*, Vol 66, Issue 6 :1123-1130

This study thus provides an indication of the transfer of PCDD/PCDF to scrubber waste matrices through measurement at both the boiler and flue gas exits. PCDD/PCDF's are reduced by around 90% by the time the combustion waste gas leaves the boiler and exits the incinerator via the scrubbing devices and stack during the start-up phase. This dioxin is largely adsorbed onto fly ash and captured in the scrubbing systems. Some PCDD/PCDF escapes in a volatile state, some is adsorbed onto particulate and yet more can be formed by post-scrubber *de novo* synthesis all of which escapes to atmosphere.

5.3 Destruction Efficiencies (DE) versus Destruction and Removal Efficiencies (DRE)

Compared to non-combustion technologies incinerators have poor Destruction Efficiencies (DE) and are commonly measured against Destruction and Removal Efficiencies (DRE). The primary reason is that incinerators have become better at removing pollutants from the stack gases by various scrubbers. The pollutants have not been destroyed merely transferred to another medium such as fly ash, filter cake, scrubber liquors or bottom ash. In evaluating the Orica export application, regulators need to assess whether the waste will be sent to a facility that produces the highest available Destruction Efficiencies or whether a better outcome can be achieved in Australia without the risks of transport halfway around the globe. For more discussion of the relative merits of DE and DRE in combustion and non-combustion technology, refer to Appendix 1.

5.4 High Temperature Incineration does not destroy HCBs, it creates new toxins

The incineration of HCB at high temperatures does not necessarily ensure its destruction. *HCB is noted for its high levels of stability even at temperatures beyond* $1000^{\circ}C$ as well as its tendency to generate reactions which give rise to a range of other persistent and toxic chemicals. Mejdoub et al (1998)¹⁶ cite a number of studies in which toxic chemicals are generated as a result of high temperature incineration. Klusmeier et al.¹⁷ identify tetrachloroethene, hexachlorobutadiene, octachlorostyrene, octachloronaphtalene, octachlorobiphenyl, octachloroacenaphthylene and parent molecules occur as decomposition products of HCB at 1000°C.

Ahling and Lindskog¹⁸ (1978) incinerated both PCB's and HCB's in a study where incinerator temperatures reached 1125°C and concluded that while PCB's could be destroyed with a residence time in the incinerator combustion zone of over 2 seconds *HCB is difficult to destroy at a temperature of 800°C even with a long transit time.* It was also shown that HCB was produced during the combustion of PCB and that the rate of its formation *increased* at high temperature.

Mejdoub et al note that HCB is often found in gaseous combustion effluents from chlorinated compounds and is often quoted as a Product of Incomplete Combustion

¹⁶ N. El Mejdoub, A. Souizi, L. Delfosse., (1998) Experimental and numerical study of the thermal destruction of hexachlorobenzene. *Journal of Analytical and Applied Pyrolysis*, 47 (1998) 77-94

¹⁷ W. Klusmeier, P. Vo"gler, K.H. Ohrbach, H. Weber, A. Kettrup, J. Anal. Appl. Pyrol. 14 (1988) 25–36.

¹⁸ B. Ahling, A. Lindskog, *The Science of the Total Environment*. 10 (1978) 51–59.

(PIC). PIC's are those pollutants that can survive high temperature incineration and can be released to atmosphere if not completely captured in flue gas cleaning equipment. Medjoub et al conclude that HCB plays an important role (as a precursor or as an intermediate) in the mechanism of formation of chlorinated dibenzodioxins and dibenzofurans. Some of them are extremely toxic and are formed during incineration of chlorinated compounds.¹⁹

In short, incineration of HCB's does not ensure their destruction and almost certainly leads to the generation of many harmful compounds that can escape to atmosphere. It is clear that incineration is a poor method by which to attempt to destroy HCB waste when better alternatives are available in Australia.

The issues raised here cast doubt over the claims that incineration of hazardous waste in Germany or other European nations have resolved the problem of dioxin emissions. The best case scenario is that incinerator dioxin emissions appear to be kept low during stead-state operation only when the 6 hour testing (EN1948) is conducted and that this occurs by transferring the dioxins to wet and dry scrubber matrices and ash.

The likely realty is that airborne dioxin emission limits are frequently exceeded by startup conditions, upset conditions, temperature irregularities and bypass conditions. This problem is compounded by the lack of more representative continuous dioxin monitoring such as the Arnesa system. Having been made aware of the likely contribution this material will make to airborne dioxin contamination within and beyond German borders, it would be highly irresponsible for the Commonwealth government to permit export of HCB waste.

However, even if the German incinerators chosen to burn the HCB are able to constantly meet the 0.1 ng/ Nm³ WHO-TEQ regulatory limit, it does not resolve the problem of dioxins and other byproducts in scrubber wastes and ash. The scrubber efficiency would only increase the concentrations of unwanted byproducts such as dioxin and furans in the incinerator residues.

5.5 Fate of contaminated incinerator ash

Community pressure to reduce airborne dioxin emissions from waste incinerators has led to higher reported efficiency and performance of dioxin scrubber technology, particularly through the use of activated carbon beds and sprays. As mentioned previously in this report, the result has been to transfer most of the dioxin contamination from the flue gases to filter or scrubber matrices such as the electrostatic precipitator (ESP's) dusts, baghouse dusts and filter cake, liquid wastes (from wet scrubbers), adsorption onto activated carbon and then finally into fly ash and to a lesser extent bottom ash.

Increasingly, there is a trend in Europe to dispose of incinerator wastes (predominantly fly ash and bottom ash and slags) via reuse schemes. Predominant among these schemes are the use of ash in construction materials such as bricks and road building materials.

¹⁹ op cit Medjoub et al (1998)

It is a major concern to our organizations that contaminated ash is being reintroduced into the environment. The European regulatory controls upon the use of bottom ash as an input to construction products and as road base are sporadic, inconsistent and difficult to enforce. The regulations are preoccupied with the leaching characteristics of ash as the only mode of bioavailability of the contaminants in final disposal or re-use modes. The leaching tests are primarily focused on heavy metals such as lead, copper and zinc rather than POPs concentrations. Volatilisation of dioxin and other POPs are not readily considered in the regulatory regime.

The European Commission is concerned that the ad hoc regulation (where it exists) of these hazardous materials has a significant likelihood of 'creating important legal and illegal transport of waste across Europe'

The rapid development of a 'recycling industry' for waste incineration residues in Europe and its haphazard regulation has become a matter for concern for the European Commission.²⁰ The Commission is concerned that the ad hoc regulation (where it exists) of these hazardous materials has a significant likelihood of *creating 'important legal and illegal transport of waste across Europe'* and that this may give rise to possible negative effects on human health and the environment. The Commission has flagged the need for harmonizing of standards and legislation across Europe to manage such materials in a safer manner.

There are also growing concerns that proposed European regulatory concentration limits for POPs in ash from incineration are set too high allowing for the possible export of contaminated ash beyond Europe to developing countries that lack the technical ability and regulatory regimes to control the fate of the waste material in the environment. This could foreshadow a return to the controversies of the 1980's with global movement of hazardous waste (in the form of incinerator ash) from developed nations to dump sites in the developing world.

Studies as far back as the 1980's confirmed that the reported generation of ash by hazardous waste incinerators ranged from 9 to 29% of the weight of wastes burned.²¹ As noted earlier, increases in scrubber efficiencies since over the last two decades will have resulted in increased ash generation from hazardous waste incinerators as well as increased concentrations of heavy metals, POPs and PICs (products of incomplete combustion).

²⁰ European Commission (2006) Management of Residues from Waste Incineration in Europe. Science for Environment Policy. *Environment News Alert Service*. February 2, 2006.

²¹ Trenholm, A., Gorman, P. & Junclaus, G. Performance Evaluation of Full-Scale Hazardous Waste Incinerators, Vol. 1: Executive Summary. USEPA, EPA-600/2-84-181a, November 1984.

Table 1PIC Contaminants identified in Bottom Ash from Hazardous Waste Incinerators 22

Parameter	Concentration (ppb)	
Acetone	20,000	
Benzene	42	
2-Butanone	2,000	
Chlorobenzene	27	
Chloroform	46	
1,2-Dichloropropane	32	
Diethyl phthalate	120,000	
2,4-Dimethylphenol	23,000	
Dimethyl phthalate	55,000	
Ethylbenzene	380	
Methanol	410,000	
Methylene chloride	38,000	
4-methyl-2-pentanone	2,300	
Naphthalene	24,000	
2-Nitroaniline	180,000	
Nitrobenzene	29,000	
Phenol	40,000	
Styrene	320	
Tetrachloroethylene	1,200,000	
Toluene	2,500	
1,1,1-Trichloroethane	12	
Trichloroethylene	120	
Xylenes	1,900	
TOTAL	2,308,679	

Heavy metals in hazardous waste incinerator ash have been a widely studied problem for many years and are the focus of regulatory measures that control the final distribution and fate of incinerator ash. Standard assessments of bottom ash for metal contamination consist of weak leachate tests (such as the ASLP) using distilled water to simulate leaching conditions in a landfill environment or the more aggressive Toxicity Characteristic Leaching Procedure (TCLP) using dilute hydrochloric acid. The focus on leachability of metal to the exclusion of other contaminant represents a serious data gap when assessing the environmental fate of incinerator ash that is reintroduced into the environment for 'beneficial purposes' such as construction materials, masonry additives and road-base.

While research during the 1980's and 1990's clearly demonstrated that heavy metals and Persistent Organic Pollutants (POP's) such as dioxins and furans were contaminating fly ash and bottom ash from municipal, hazardous and medical waste incinerators, since then researchers have discovered a much broader range of contaminants in the Air Pollution Control (APC) residues such as dust and scrubber water.

²² Boegel, J. Assessment of Residues from Incineration of RCRA Wastes. In: Land Disposal, Remedial Action, Incineration, and Treatment of Hazardous Waste, Proceedings of the Thirteenth Annual Research Symposium, USEPA Hazardous Waste Engineering Laboratory, Cincinnati, July 1987, EPA1600/9-87/015.

Scrubber waters also contain elevated pollutants that are extracted through wet scrubber systems designed to capture contaminants in the flue gas train. The following table identifies some of the more hazardous pollutants reported in scrubber water from a US hazardous waste incinerator. It should be noted that phthalates feature prominently and continue to be investigated or their potent endocrine disruption capabilities

Table 2 Pollutants Found In Scrubber Effluents from Hazardous Waste Incinerators

Pollutant		Wastewater s per litre)
Acetone	32	(1)
Methylene Chloride	<5	(1)
Naphthalene	<20	(1)
Benzoic acid	260	(2)
Bis (2-ethylhexyl)phthalate	32	(2)
Chloroform	4,100	(2)
Chloromethane	2,500	(2)
1,2-Dichloroethane	32,000	(2)
Diethyl phthalate	30	(2)
Di-n-butyl phthalate	22	(2)
Phenol	100	(2)
Tetrachloroethane	5,200	(2)
Toluene	5,000	(2)
1,1,1-Trichloroethane	6,800	(2)
Trichloroethene	14,000	(2)
Total xylenes	1,200	(2)
Dioxins and furans (total)	43	(3)

5.6 Risk Associated with Current Disposal Practices for Incinerator Residues

A recent report by IPEN²³ demonstrates major problems with the unregulated and partially regulated use of incinerator ash in Europe as a construction material. In the Netherlands, fly ash is a major route for dioxin releases from waste incineration to the environment. For the year 2000 the quantity of dioxins in ash is estimated at 2671 g I-TEQ/year (this figure includes dioxins in bottom ash and filter residues.)²⁴ The levels of heavy metals and POP's and other toxic compounds found in Netherlands fly ash is outlined below.

²³ Petrlik, M.S.J. and Ryder, R., (2005) After Incineration – The Toxic Ash Problem. The International POP's Elimination Network "Keep the Promise, Eliminate POPs!" Campaign and Dioxin, PCBs and Waste Working Group of the International POPs Elimination Network (IPEN) Report ²⁴ ibid p.17

	Average levels in fly ash (mg/kg)	Number of samples analyzed	Average levels in bottom as
			(mg/kg)
aluminium (Al)	30,294	17	Not defined
arsenic (As)	97	17	19-23
cadmium (Cd)	379	17	2-8
chromium (Cr)	231	31	235-296
copper (Cu)	1,154	17	669-3212
mercury (Hg)	2	17	0.03-0.2
lead (Pb)	7,671	17	1086-1637
molybden (Mo)	50	17	5-11
selenium (Se)	9	17	0.4-0.5
strontium (Sr)	245	17	Not defined
tin (Sn)	1,007	17	62-77
vanadium (V)	30	27	40-52
wolfram (W)	77	17	Not defined
zinc (Zn)	22,488	17	1239-2125
bromine (Br)	997	17	Not defined
chlorine (Cl)	74, 471	17	1050-2445
fluorine (F)	57	17	Not defined
dioxins (PCDD)	0.0024	17	Below detection
and furans (PCDF)	(in I-TEQ)		limit

Average composition of fly ash and bottom ash from Dutch waste incinerators in 1997 (in mg/kg)²⁵

With the regulatory focus on ash leachability little information is available on the projected environmental impacts of ash contaminants once the 're-use' option ends its useful life. Virtually no information is available on the fate of contaminants that have been introduced into construction materials when demolition and destruction of the building materials occur. Certainly in Germany there are many plants dedicated to ash processing and bitumen reprocessing. In the industrialized North-Rhine Westphalia Region there are 115 reprocessing plants for bitumen and mineral based construction wastes and 43 plants processing ashes and slags.

In May 2002, the (British) Environment Agency²⁶ published a report on concerns with the use of incinerator ash following well publicised incidents of reuse of incinerator ash at Edmonton, North London, and Byker, Tyneside.

The report estimated that dioxin levels in blocks made from bottom ash would be around 4ng TEQ/kg (compared to 1ng for blocks made out of power station ash), though one block was actually measured at 23ng.

²⁵ ibid. p.16

²⁶ Environment Agency, Solid Residues from Municipal Waste Incinerators in England and Wales, May 2002.

Although the practice ceased in 2000 both bottom and fly ash from the Edmonton incinerator was mixed and used to form construction blocks. Around 15,000 tonnes was used to make construction blocks (estimated at 5.3million blocks, enough to build 3,400 houses). Dioxin in the blocks was measured in the range 117-390ng TEQ/kg.

A house constructed of these blocks was studied. With normal air flow, no measurable difference in dioxin levels was observed.

However, continuous drilling did produce dust which could cause significant levels of dioxins for builders or people doing DIY (do it yourself) renovations. The report concludes that builders drilling would need to be exposed over long periods to put them at risk, so normal exposure would be too short lived to be a major concern.

A major recommendation of the report was that standards need to be developed to define the permissible concentrations of PCDD/DF in building products, effectively arguing that the market had moved ahead of regulation. Similar concerns were echoed in the European Commission News alert cited previously.

NTN is among many other organisations concerned about the risks that contaminated ash presents to:

- workers at the re-processing operations
- workers involved in construction and maintenance of roads and buildings using contaminated materials
- · demolition workers handling contaminated road base and building waste
- people residing in dwellings constructed of contaminated products
- environmental effects of final disposal of contaminated waste from demolition

The precautionary principle should require that any construction products incorporating contaminated ash be assessed against a full life-cycle analysis incorporating the exposure scenarios identified above.

5.7 Salt Mine Disposal

Since it is becoming more and more difficult to build hazardous waste dumps in the face of public protest, politicians are looking for new ways of dealing with the accumulating incineration residues. Closed-down mines in the Ruhr are being used as deposits for highly poisonous filter dust. 6 million tonnes of waste are scheduled to be deposited there within the next few years. The citizenry does not have any participatory power in the planning process because special mining laws apply that exclude the public and because the highly noxious hazardous waste has been declared an economic resource. What is stored in the mines cannot be taken out again. If the poisonous substances get into the ground water and thus poison the drinking water, the waste stored there cannot be removed.²⁷ Problems have been encountered with water intrusion into former salt mines

²⁷ Dioxin in Germany - by Barbel Hohn, Speaker of Green Parliament List, North Rhine-Westphalia, Germany Available from *Synthesis/Regeneration*, A Magazine of Green Social Thought online < <u>http://www.greens.org/s-r/078/07-52.html</u> >

and concerns are now being raised about their suitability for long term storage and disposal of hazardous waste. RZR Herten will dump their toxic ash at Heilbron underground waste dump.

5.8 Four Incinerators Identified for the Orica HCB waste

On the basis of information obtained from the Orica Application for Basel Permit the four incinerators are:

- Bayer Industry Services GmbH & Co OHG, Leverkusen Germany
- Bayer Dormagen
- AGR Entsorgung GmbH RZR Herten, Herten Nordrhein-Westfalen/Kreis Recklinghausen
- SAVA Sonderabfallverbrennungsanlagen GmbH

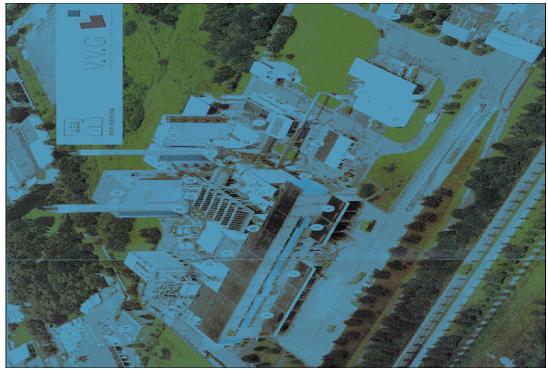
Due to the variable nature of the wastes Orica intends to incinerate different types of HCB wastes at one or more of the incinerators listed above. he different forms of waste are categorised according to the European Council Regulations below:

(a) EU Code 07 01 07: halogenated still bottoms and reaction residues.

(b) EU Code 15 01 10: packaging containing residues of or contaminated by dangerous substances.

(c) EU Code 17 09 03: soil and stones containing dangerous substances.

The RZR Herten incinerator is listed to take 4000 tonnes of halogenated still bottoms and reaction residues, 200 tonnes of packaging containing residues of dangerous substances and 850 tonnes of contaminated soil.



RZR Herten High Temperature Incinerator

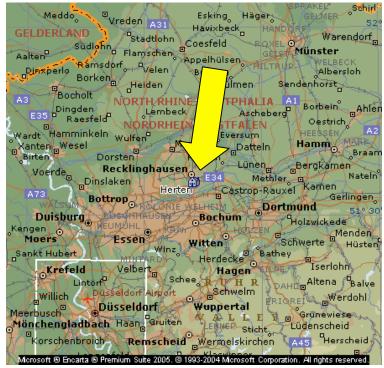


Figure 7 RZR Incinerator at Herten



Underground waste dump for ash from RZR Herten Incinerator located at Heilbronn and operated by the South-West German Salt Works (in partnership with RZR Herten)

Mörlenbad, HESSE Ebersberg Beuchen Höpfingen Dittigbeim Weinheim Straßburg Mudau Buchen Königshofen Reisfeld Viernhreim Straßburg Mudau Buchen Königshofen Reisfeld A67 A5 Altenbach Eberbach Limbach Bad Mergentheim Wachbach Bruhn Grein Meckarhausen Osterburken A31 Schwabhausen Heidelberg Lohrbach Adelsheim Wemmershof Hohebach Leimen Bommental NCKAR Neudersau Künzelsau Steinbach Rot A5 Rot A5 Bruchsal Stebbach Neckarsulm Walber Bruchsal Stebbach Heilbronn Baumerlenbach Bruchsal Stebbach Heilbronn Bruchsal Stebbach Backnang Flein Wüstenrot Hall Bretten Knittlingen Großbottwar der Murr Muhlacker Lingen Backnang Flein Wüstenrot Hall Bretten Knittlingen Großbottwar der Murr A1 Mühlacker Lingen Backnang Flein Bauthardt Münster A3 Mühlacker Lingen Backnang Flein Baltmannsweiler Altenberg Ludwigsburg Freiberg am Neckar of Heisenstein Buckstaft Older Backnang Crauspach Muhlacker Lingen Backnang Crauspach Altenberg Baltmannsweiler Heubach Muhlacker Bingen Backnang Crauspach Muhlacker Bingen Backnang Crauspach Altenberg Althengstett Ostfildern Baltmannsweiler Heubach Musen Bingen Baltmannsweiler Heubach Schwäbisch Gründ Buch Sterberg Schwäbisch Gründ Buch Sterberg Musen Bisten Baltmannsweiler Heubach Startsbad of Lack Bernheim Bisten Baltmannsweiler Heubach Startsbad of Lack Bernheim Bisten Baltmannsweiler Heubach Startsbad of But ACK Bernheim Bisten Baltmannsweiler Heubach Startsbad of But ACK Breiter Breither Stuttgart Baltmannsweiler Heubach Startsbad of Breiter Breither Stuttgart Baltmannsweiler Heubach Startsbad of Breither Breither Bernhardster Destingen Baltmannsweiler Heubach Startsbad of Breither Breither Bernhardster Distributer Baltmannsweiler Heubach Stuttgart Baltmannsweiler Heubach Startsbad of Breither Brei Microsoft D Encarta D Premium Suite 2005. @ 1993-2004 Microsoft Corporation. All rights reserved.

Site of Underground toxic dump at Heilbron



SAVA incinerator Brunsbuttel

The SAVA GmbH incinerator at Brunsbüttel is also listed to take 4000 tonnes of halogenated still bottoms and reaction residues, 200 tonnes of packaging containing residues of dangerous substances and 850 tonnes of contaminated soil.

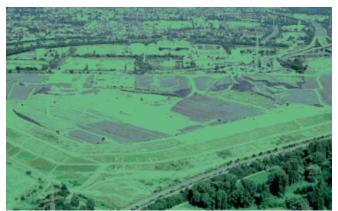


Bayer complex - Dormagen

The Bayer incinerator at Dormagen is listed to take 2000 tonnes of halogenated still bottoms and reaction residues while the Bayer incinerator at Leverkusen is listed to take 3600 tonnes of halogenated still bottoms and reaction residues.



Bayer Complex – Leverkusen



Bayer Incinerator and Hazardous Waste landfill at Leverkusen-Burrig

According to the international NGO *Coalition Against Bayer Dangers*, BAYER is one of the biggest water polluters and water consumers in Germany. With its effluent, the company emits around 830 tons of phosphorus, 2,800 tons of nitrogen, 1 million tons of inorganic salts, 73 tons of organic chlorine compounds and 28 tons of heavy metals every year. Each day, the BAYER Group uses some 2.3 million cubic meters of water. The Leverkusen site alone produces twice as much effluent as the neighboring city of Cologne, which has over a million inhabitants. Most of the company's sites remove high-quality groundwater from the soil and because of "old water rights" do not even pay for it. This catastrophic situation did not stop BAYER from initiating a "research program for water protection" last summer together with National Geographic. The research program can be regarded as a fig leaf with which the company seeks to detract from its poor environmental performance.²⁸

Vinkrath BOCKUNT NORTH RHINE WESTPHALIA Berge Spectruk Tonisvorst Krefeld Eggescheidt Üllendabt Gevelsberg AS Grefrath Sankt Tonis Lank-Latum B Heiligenhaus Dönberg B
Wiercen / BOHAUSEN WICHTENBROICH Schweim
Bouken Bouken Kaarsta Bener Brikrath Br
DAMM / CONSTRUCT AUSTROBAL W
VENH Mönchengladbach DIT ENER ESS Haar VALLEY Ahe Ludenscheid RHE DT Korschenbroich Brit Ister Solingen Aue Remscheid
HELPENSTERN WECK WEN HONSCHEID
Openkirkeli
Oppkel Reh Jüchen Jüchen Erkelenz Elsen Grevenbroich Dormagen Balt Dormagen Do
Rucknoven Benninghausen Kodt
Tenholt Rommerskirchen SegenDorf Altenberg Gimborn
Tetz Oberaußem Brauweiler weiler Bergisch E40 A4
Tetz Mersch Höllen Bergheim Cologne Muterin Gladbach Overath Wiehl Feld.
Dulich Esch Elsdorf Frechen BAON Step E35 Marialinden Oberdorf
Bourheim Niederzier E40 Kernen Hürthe Houndern Cologne Seelscheid Waldbröl
Inden Ellen Buir Bergerhausen auch Mescherrich und Hermerath Ruh
Tetz Oberaußern Brauweiler Bergisch Bergisch Bergich Bergheim Cologne Bergisch Overath Wiehl, Feld, Builtich Esch Elsdorf Frechen Frechen Oberzier Oberzier Oberzier Julich Esch Elsdorf Frechen Hürth Esch Elsdorf Oberzier Oberzier Bourheim Niederzier E40 Kerpen Kerpen Cologne Oberzier Waldbrölg Inden Bergerhausen Brühl Bourheim Bergerhausen Brühl Bergerhausen Velken Frenz Merzenich Bergerhausen Brühl Esch Elsdorf Velken Langerwehe Morsoft Genoata B Penlum Solte 2005 (B 1993-2004 Morsoft Coporation, Allingits reservet) Velken

Bayer incinerators at Dormagen and Leverkusen

²⁸ http://www.indymedia.org.uk/en/2006/03/336452.html

SECTION 6. THE OPTIONS FOR HOME GROWN NON INCINERATION TECHNOLOGY

Australia has two non-incineration technologies with the capability to destroy the HCB waste. There is no need for export to Germany.

6.1 Available Technology in Australia

Australian waste treatment companies have already demonstrated that the capability to treat POPs waste such as HCB to a high level of Destruction Efficiency (DE) without incineration. In the past decade the Eco Logic Gas Phase Chemical Reduction process in Kwinana, WA, destroyed Australia's major stockpile of PCBs. While that technology is no longer available in Australia, it has been replaced by other suitable technologies.

More recently Australia reached agreement with Pacific Island nations to bring back to Australia POP's waste including PCBs and POP's pesticides, much of which had primarily originated from Australia in the past. These POPs wastes were successfully treated by BCD Technology Pty Ltd based at Narangba in Queensland.

This utilized two currently capable of treating the HCB waste in Australia are;

- Base Catalyst Dechlorination (BCD)
- Plasma Arc destruction (Plascon)

Orica is aware that both of these technologies are available in Australia and have even sent HCB waste samples to one company who successfully treated the waste using plasma arc technology. NTN has a copy of recent correspondence from DoloMatrix²⁹ Australia Ltd (owners of both the Plasma Arc technology and the BCD plant) indicating that its Plascon unit can achieve destruction efficiencies of 99.9999% for chlorinated compounds.³⁰

According to this correspondence, the Plascon unit has already successfully destroyed HCB waste provided by Orica and DoloMatrix seeks to continue the program and scale

²⁹ Correspondence - DoloMatrix to Orica, 5 Sept 2006.

³⁰ As noted earlier German incinerators cannot come close to these efficiencies due to transfer of POP's to the ash and scrubber waters. This is why they have Destruction and Removal Efficiency standards (DRE) to disguise the lack of destruction capability of incinerators

up for destruction of the stockpile. It appears that Orica has failed to notify the Australian Federal authorities of this information. Under the *Hazardous Waste Act*, Orica cannot export the waste if adequate treatment processes are available in Australia.

In order for either Plascon or BCD technology to destroy the entire HCB stockpile an intermediate technology is required. In the past both Plascon and BCD technology have been trialed in Australia on HCB waste and found to have acceptably high DE. Orica has claimed that these technologies are only capable of treating the high concentration wastes in liquid forms. The Orica waste stockpile also contains large amounts of contaminated soil, rubble, packaging, concrete and personal protective equipment. Orica contends that the Plascon and BCD technologies do not have the capacity to accept these other materials through the feed manifolds to the reactors.

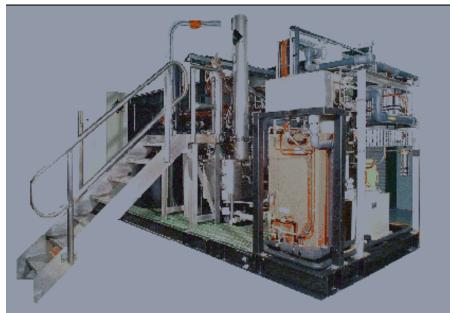
An intermediate technology known as Indirect Thermal Desorption Units (ITDU) provides a solution to this problem. One of the best examples of how these technologies can combine is found in the Spolana site in Czechoslavakia. The Spolana chemical manufacturing complex is one of the most polluted in the world (more on this below) with high concentrations of dioxin, HCB, pesticides and other POPs in soil, demolition rubble, concentrates and other forms.

High temperature incineration was ruled out at the Spolana site as it was considered a diffuser mechanism that did not necessarily destroy the POPs but transferred them to ash and other residues of the incinerator which ultimately ended up in the environment.

A combination of two technologies, Base Catalyst Dechlorination (BCD) and Indirect Thermal Desorption Units (ITDU) overcame the issue of difficult feedstocks. The ITDU (see Fig 12 below) uses a rotating kiln to heat the contaminated rubble, soil or other materials to a temperature (usually 500-600° C) in the absence of oxygen to strip the POPs from the other wastes where they are then collected in a filter and condensed. The resulting concentrate of POPs are then removed and fed into the BCD plant (as in Spolana) or into a Plasma arc such as the Plascon unit in Queensland.

6.1.1 What is Plascon (Plasma Arc) technology?

Plascon is an in-flight argon plasma arc used for the destruction of organic wastes including liquids and gases. The process inputs of electricity, argon, oxygen or steam and sodium hydroxide are significantly less than those required for a similar sized high temperature incinerator. Process effluents are also considerably less. Liquid effluents are hydrochloric acid that can be recovered for sale. Gaseous effluent is a mixture of argon, carbon gases and water vapour.

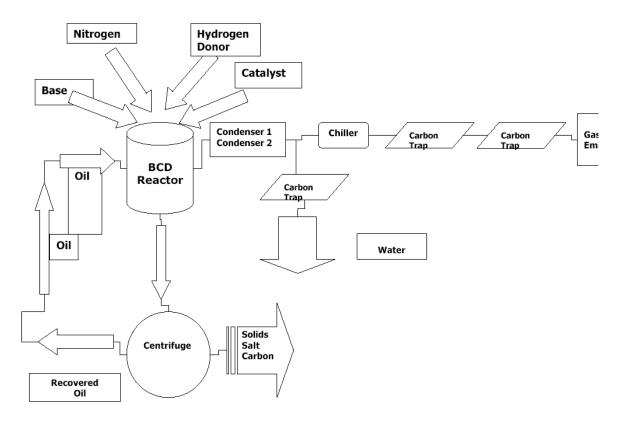


The plasma torch³¹ is of segmented design using argon as the plasma gas. The argon plasma is generated by a direct current discharge between cathode and anode. At typical operating conditions the mean exit temperature is in excess of 10,000°C. The torch is rated at 150kW and has an electrical efficiency of around 50%. Argon is used as the plasma gas as it has suitable thermodynamic properties, is monatomic and for its inertness to the torch components³². For more detailed information see Appendix 3.

6.1.2 What is BCD technology?

Base Catalyst Dechlorination (or Decomposition) is a process where organochlorines are reacted with an alkaline polyethylene glycol, forming a glycol ether and/or a hydroxylated compound, which requires further treatment, and a salt. A schematic at Figure 11 describes the basic elements of the process. For more detailed information see Appendix 2.In order to feed the BCD reactor the HCB material must first be dissolved in mineral oil and is then fed to the reactor through a manifold of the appropriate temperature to maintain the HCB waste in a liquid form. Significant improvements have been made with the technology (such as in Spolana) to improve the recovery of oil used in the process above 90%.³³

 ³¹ SRL Plascon technology http://www.ihpa.info/docs/library/Pops/SBCPLASCONDEF_161105_.pdf
 ³² Op cit Correspondence - DoloMatrix to Orica 5 Sept 2006. p.7
 ³³ Vijgen, J., International HCH and Pesticides Association. *Presentation on Non-Incineration Technologies for POP's* Destruction. 2006



BCD Reactor schematic³⁴

6.2 Why has Orica rejected these technologies?

The real reason that Orica has chosen to overlook these technologies is not clear. It may be a commercial decision. While the cost of export and destruction of the wastes in Germany has not been revealed some general costs for the alternative technologies is available.

- BCD (Spolana): 1400-1700 US \$/t for organochlorines with a Chlorine content of 50% (150 tonnes/month)
- BCD (Australia) \$Au250-\$1000 p/tonne
- PLASCON (NUFARM/AUSTRALIA) 1 and 3 tonnes per day ca 3000 US \$/tonne pure waste.³⁵

The prices are indicative only and may be subject to significant variation on a contractual basis.

6.3 'Designed to fail' - Orica's process to find site Geomelt in New South Wales

³⁴ ibid

³⁵Note that this refers to the Nufarm Plasma Arc and not the Dolomatrix plasma arc.

In 2000, Orica chose its preferred technology to build at the Botany Industrial Site. It rejected the well tried, community supported technology, ECOLOGIC Gas Phase Chemical Reduction (GPCR) Process. It chose instead an untried, semi-incineration vitrification process which led to local community concern and the rejection of the Environmental Impact Statement. The New South Wales Commission of Inquiry was established and directed Orica to find an alternative site in New South Wales.

Orica claim that the process to find an alternate destruction site in remote NSW failed due to lack of community support for the establishment of a process to destroy the HCB waste by the incineration/vitrification method described above. Orica met with a number of potentially interested local government representatives who objected that they would have to accept all the risks posed by the untried technology while there were effectively no local benefits to be gained from the exercise. They also cited potential threat to crop and livestock export certification as a reason to reject the proposal. The threat being residual contamination of agricultural commodities by emissions from the proposed Geomelt treatment process. Orica ran a siting process for Geomelt treatment of HCB waste that was always doomed to failure due to the choice of an untried semi-incineration technology. The failure of this process is now being used by Orica as an excuse to fast-track the export of HCB to Germany.

This narrow approach failed to consider alternative non-combustion technologies that are available in Australia or upgrades of existing local technology to standards that are effectively treating HCB waste in Europe to high DE levels.

Evidence is now available that the BCD facility based in Brisbane can be upgraded to meet the standards being achieved by the BCD technology operated by TSCR in Spolana, Czech Republic.³⁶ Despite claims by Orica that the BCD and Plascon technologies cannot accept the diversity of waste types in the HCB stockpile, it is evident from the preceding argument and from the case study of Spolana below, that this is not the case and either of the Australian technologies can be upgraded in the short to medium term to accept the HCB waste.

6.4 The Spolana Experience – BCD technology and Indirect Thermal Desorption

Within the massive Spolana chemical complex flanking the Elbe River at Neratovice, 30km north of Prague, is a 17 hectare plant once used to make Agent Orange and other herbicides, as well as pesticides. Spolana produced dioxin contaminated chlorinated compounds including the so-called Seveso dioxin, a by-product of herbicide production, during a three-year period during the 1960s. When production was abandoned, the buildings were sealed, and scant attention was paid to the hazard until August 2002, when severe flooding raised concerns that the contaminants could be washed into the river and cause widespread hazards to health.

³⁶ Chris P Wynne, Director, TCSR >CWynne@abricon.com> '

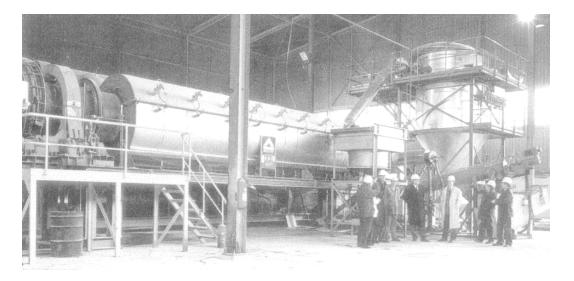
The Czech government put up US\$90 million to decontaminate the plant, using technology from a British company, TCSR, working in partnership with French contractor Suez Environment.

Part of the challenge was to process the toxins on site, without disrupting output from the neighbouring PVC plant, which employs 1,000 people. An Indirect Thermal Desorption (ITD) unit was built on site. This technology separates organic pollutants from soil and other materials in a rotating drum without direct contact with the heat source.

Using patented technology from TCSR, a Base Catalysed Decomposition plant was also assembled for the first time in Europe to break down chlorinated hydrocarbons chemically. Its end products: salt, water and carbon.

A shell building was built over the contaminated areas, allowing a negative pressure as workers in special suits and breathing apparatus remove contaminated soil, materials, and ultimately the plant itself, for treatment in the processing facility.

The aim of the work, which will take another two years to complete, is to process an estimated 35,000 tonnes of contaminated soil and materials and leave a site fit for re-use.



The Thermal Desorption Unit (TDU) at Spolana.

The thermal desorption unit heats contaminated materials to 500-600 C stripping in absence of oxygen and POPs are collected in filter and condensation system. The BCD unit (see below) then treats this concentrate.



The BCD Unit at Spolana

The tables below demonstrate the high Destruction Efficiencies achieved by the BCD unit for HCB, lindane and dioxin at Spolana.

Destruction capability of HCB & Lindane

Material	Inlet mg/kg		Outl	Outlet Oil Matrix mg/kg	
	HCB	Lindane	HC	CB Lindane	:
Chemical waste	29,000	1,500	<	1.0 < 1.0	
Chemical waste	200,000	900	<	2.0 < 2.0	
Chemical waste	550,000	1,000	<	2.0 < 2.0	
Chemical waste	270,000	1,000	<	2.0 < 2.0	
Chemical waste	160,000	1,000	<	2.0 < 2.0	
Dust	7,607	7	<	2.0 < 2.0	
Chemical waste	1,598	19,000	<	2.0 < 2.0	
Concentr Aqueous	630	< 2.0	< 2	2.0 < 2.0	
Concentr Organic	11,000	< 2.0	<	2.0 < 2.0	

Dioxin destruction rates

Material	Inlet ng/kg I-TEQ	Outlet Oil Matrix ng/kg I-TEQ
Chemical waste	209,000	0 (Reported value)

Chemical waste	200,000	4.3
Chemical waste	11,000	0.23
Chemical waste	47,000	0
Chemical waste	35,000	0
Dust	1,620,000	0.52
Chemical waste	78,000	0
Concent Aqueous	96,000	0
Concent Organic	876,000	0

The tables below indicate the stripping capacity of the Indirect Thermal Desorption Unit at Spolana, a necessary first step in removing and concentrating the POPs from heterogeneous waste matrices such as soil, rubble and concrete.

Treatment of Solid Matrices in Upstream Desorber -HCB & Lindane Removal

Material	Inlet mg/kg		Outlet 1	ng/kg
	HCB	Lindane	НСВ	Lindane
Soil	2,643	1.34	< 1.0	< 1.0
Brick& Concrete	49,000	11	< 1.0	< 1.0
Concrete	5,100	18	< 1.0	< 1.0
Plaster	270	< 1.0	< 1.0	< 1.0

Treatment of Solid Matrices in Upstream Desorber - Dioxin Removal

Material	Inlet ng/kg I-TEQ	Outlet ng/kg I-TEQ
Soil	46,500	2.9
Brick& Concrete	2,420,000	6.3
Concrete	4,780,000	66.0
Plaster	3,800	5.6

The Spolana experience is but one of a number of emerging projects for POPs destruction that are seeking to avoid the use of high temperature incinerators due to their poor destruction efficiencies. The United Nations Development Programme (through the Global Environment Facility) is also encouraging non-incinerator alternatives for POPs destruction. The Slovakia project is another example of the growing range of nonincineration technologies being commercialized internationally.

In the words of UNIDO, the "Slovakia Project will build on the significant level of Civil Society involvement that has begun during project preparation and also on the Australian experience where public policy is to avoid the use of incinerators for the destruction of hazardous wastes and to involve Civil Society in the approval and the operational oversight of selected destruction technologies. As a result of the Australian experience, groups within Australian Civil Society that had vigorously opposed incineration and/or land burial of PTS-containing wastes participated in the decisions to utilize these newer technologies, participated in reviews of these technologies, and generally accepted them. The Australian experience resulted in a remarkable level of Civil Society agreement (Government, industry, international, national and community-based NGOs) on the successful deployment of a Non-combustion approach to the destruction of Australia's PCB containing equipment and wastes, and can be viewed as a model "barriers reduction" effort. Early indications from this Programme and Project show similar promise for achieving strong Civil Society support for the activities that will be undertaken in the participating countries."³⁷

CONCLUSION

The proposal by Orica to export thousands of tonnes of highly toxic HCB waste to Germany for incineration is unacceptable and should be rejected. Suitable destruction technologies already exist in Australia that can not only destroy the HCB waste but can do so in a way that achieves a far better environmental outcome than incineration in Germany (which operates on a principle of dispersion of wastes to the environment). Treatment in Australia also avoids most of the risks associated with transport of the waste across the globe and through Germany.

Given that treatment technologies in Australia are available for the destruction of the HCB waste it is arguable that *exceptional circumstances do not exist* and any approval to export the HCB waste may be illegal and subject to challenge.

NTN therefore requests that the Federal Minister for the Environment considers this controversial proposal carefully, and fully examines the options for domestic treatment. Any reasonable assessment of this HCB export proposal must lead to its rejection. NTN, as the principle objector on behalf of hundreds of organisations in Australia and internationally, strongly urges the Minister to reject this proposal outright.

³⁷ United Nations Development Programme, Global Environment Facility, Government of Slovakia Project Document, 21 November 2005 ' Non-combustion Demonstration project in Slovakia', Executing Agency: United Nations Industrial Development Organization (UNIDO)

Appendix 1 Destruction Efficiencies of Non-incinerator technologies.

Following taken from United Nations Development Programme, Global Environment Facility, Government of Slovakia Project Document, 21 November 2005 'Noncombustion Demonstration project in Slovakia', Executing Agency: United Nations Industrial Development Organization (UNIDO)

"Innovative, highly effective technologies for the useful and appropriate environmentally sound destruction and decontamination of many types of persistent toxic substances (PTS), especially POPs, that do not utilize combustion processes, have recently emerged and been commercialized. Some of them have operating characteristics that make them far superior to incineration, as they possess a much higher destruction efficiency, or DE, operate in an essentially closed system, provide greater worker safety, and can handle a wider range of matrices. They appear to be capable of performing in ways that avoid problems that have been associated with the expert and public opposition to incineration and other combustion technologies.

These innovative technologies can directly destroy and decontaminate POPs that are present in different matrices in obsolete chemical stockpiles and in contaminated wastes and can be combined with other cleanup technologies to destroy POPs trapped in soils and sediments. A consensus of opinion that is very positively inclined towards these innovative, noncombustion POPs destruction and decontamination technologies is emerging at the international level, but this positive inclination is tempered by the realization that a number of barriers have to be overcome before these technologies can be effectively and competitively deployed. This topic was given a detailed review by a recent technical workshop of the Scientific and Technical Advisory Panel of the GEF (STAP/GEF) held in Washington D.C., 1-3 October 2003. A summary of the technical workshop is given in Annex 2d.

UNEP Chemicals also organized, with support from the Swiss Government, a consultation meeting in Geneva, 9-10 June 2004 to discuss upcoming international needs for PCB management and disposal in the context of the Stockholm Convention. The meeting discussed, with the participation of GEF Implementing Agencies and PCB-related industry representatives, the international policy framework, logistical issues and available capacities in relation to PCB storage, management, transport and disposal. It greatly facilitated the dialogue between industry owners of PCB-containing equipment and sectors involved in the promotion and application of non-combustion technologies for PCB management and disposal. Other interested international organizations, bilateral development assistance donors, NGOs and developing countries and countries with economies in transition also contributed to the agenda.

Total destruction efficiency₂ (DE) is almost never reported or calculated for incinerators, cement kilns and other combustion technologies because these devices typically fail to achieve high total destruction efficiencies. Rather, most regulatory agencies only require a measure of the so-called "*destruction and removal efficiency*" (DRE). This measure only takes into account contaminants that are present in the stack gases (air emissions), but ignores toxic contaminants of concern released as solid and liquid residues (as waste ash, sludge and

waste water). Modern incinerators achieve high reported DREs by using filters, scrubbers and other stack gas cleaning devices to capture pollutants of concern, remove them from the device's gaseous emissions, and transfer them to solid waste and/or liquid waste residues. As a result, when only a device's DRE is considered, and when a measure of its total DE is avoided, this encourages the selection and deployment of technologies that transfer contaminants from stack gases into other media (water and ground). The use of DE as a measure, on the other hand, encourages the selection and deployment of technologies that efficiently destroy and eliminate POPs and other organic pollutants to be otherwise, intentionally or unintentionally, released into any environmental media.

The controversy about land burial technologies revolves around differing estimates of the integrity and longevity of the containments and the amount of volatilization and/or leaching of POPs and similar substances that can be expected from the land burial site over the long term.

APPENDIX 2 BCD Technology and Variants.

CMPS&F - Environment Australia Appropriate technologies for the treatment of scheduled wastes Review Report Number 4 - November 1997

5. BASE CATALYSED DECHLORINATION

- <u>5.1 Introduction</u>
- 5.2 The BCD Process
- <u>5.3 Thermal Desorption Prior to BCD Treatment</u>
- 5.4 BCD Variants
- <u>5.5 Summary</u>

5.1 Introduction

The Base Catalysed Dechlorination (BCD) 1 process, was developed to treat halogenated organic compounds. The process was developed from work by the USEPA on earlier forms of dechlorination (in particular the "KPEG" process). This work was undertaken at the Cincinnati Risk Reduction Research Laboratory. The proponents claim BCD is suitable for treatment of wastes which contain up to 100000 mg/kg of halogenated aliphatic or aromatic organic compounds such as PCBs. In practice, the formation of salt within the treated mixture can limit the concentration of halogenated material able to be treated. Reduction of chlorinated organics to less than 2 mg/kg is achievable (Rogers, 1991).

The BCD process can involve direct dehalogenation or decomposition of the waste material, or can be linked with a pretreatment step such as thermal desorption which yields a relatively small quantity of a condensed volatile phase for separate treatment by the BCD process.

5.2 The BCD Process

5.2.1 Technology Description

The following description of the BCD process focuses on the BCD process applied either to the waste itself or to the separated volatiles from a preceding thermal desorption process. The description has been drawn from the BCD patent application (Rogers, 1991) and indicates some possible process variations. ADI Limited (ADI) in particular, has

undertaken a considerable quantity of work aimed at refining elements of the process. In the following section, the application of thermal desorption for pretreatment of wastes is discussed.

The BCD process involves the addition of an alkali or alkaline earth metal carbonate, bicarbonate or hydroxide to the contaminated medium containing one or more halogenated or non-halogenated organic contaminant compounds. The BCD patent indicates that the alkaline chemical may be added to the contaminated medium in an aqueous solution, or in a high boiling point solvent. If the chemical is added in the form of a solid dispersion or suspension in water, the water assists in distributing the metal compound homogeneously throughout the contaminated medium. If the chemical is added with a high boiling point solvent, the solvent must have a boiling point of at least 200°C, and preferably be in the range from 200°C to about 500°C. Otherwise, it will distil from the mixture during treatment.

Alkali is added to the contaminated medium in proportions ranging from 1 to about 20 percent by weight. The amount of alkali required is dependent on the concentration of the halogenated or non-halogenated organic contaminant contained in the medium.

A hydrogen donor compound is added to the mixture to provide hydrogen ions for reaction with the halogenated and non-halogenated contaminants, if these ions are not already present in the contaminated material. The hydrogen donor compound may comprise the high boiling point solvent in which the alkali or alkaline earth metal compound is added, or it may include fatty acids, aliphatic alcohols or hydrocarbons, amines or other similar compounds. In order to activate these compounds to produce hydrogen ions a source of carbon must be added, either in solution or in suspension. An inexpensive carbon source which is water soluble and suitable for use, is a carbohydrate such as sucrose.

The mixture is heated at a temperature and for a time sufficient to totally dehydrate the medium. This may be performed at atmospheric or at reduced or elevated pressure. The water which is included in the aqueous solution allows homogeneous distribution of the alkali throughout the mixture and acts as a wetting agent and penetrant. When the water is removed from the medium during the dehydration step, the alkali is concentrated to a reactive state.

After dehydration, the medium is further heated at a temperature between 200°C and 400°C for a time sufficient to effect reductive decomposition of the halogenated and non-halogenated organic contaminant compounds, typically 0.5 to 2 hours. At this temperature the carbon source (eg the carbohydrate) acts as a catalyst for the formation of a reactive hydrogen ion from the hydrogen donor compound. This catalysed reaction is represented by the following reaction formula:

$$R + M \xrightarrow{200 - 400^{\circ}C} R + H^{-} + M^{+}$$

where R is the hydrogen donor compound, M is the metal compound, C refers to a source of carbon, for example a carbohydrate, and H is the hydride ion. The reactive hydride ion then reacts with the halogenated organic compounds contained in the contaminated medium according to the following reaction:

 $H + R - X + M^+ \xrightarrow{200 - 400^{\circ}C} RX + R - H$

where R-X is the halogenated organic contaminant, X is the halogen atom and R-H is the reduced form of the contaminated compound.

Finally, the mixture is neutralised by the addition of an acid, preferably to a pH of 7 to 9. Depending on the nature of the feed material, the reagent additions and the site use, it may be possible for the treated material to be returned to the site if desired, although this may not be possible if the treated material is oily or has a high salt content.

Generally, oxygen will not adversely affect the BCD process and therefore air does not need to be excluded. When applied to the decontamination of hydrocarbon fluids, either aliphatic or aromatic, air needs to be excluded in order to prevent ignition of the hydrocarbon at the elevated temperature of the BCD reaction. This is achieved by passing nitrogen gas through the reaction vessel.

Given the process employs relatively small amounts of alkali and solvent (if used), recovery of excess reagents for reuse is not generally proposed. The treatment is usually carried out as a batch process with all steps completed within a single reactor.

5.2.2 Performance

Test results show that the BCD process is able to reduce PCB from 10000 mg/kg to below detectable limits in approximately 2 hours (Rogers, 1991). A sample of contaminated soil containing 2,200 mg/kg of Aroclor "1260", 1000 mg/kg of Aroclor "1242", 1000 mg/kg of PCP, 1000 mg/kg of dieldrin, 1000 mg/kg of lindane and 500 mg/kg of 2phenylnaphthalene, was treated by this process and the contaminants reduced to less than 1.0 mg/kg each. The 2phenylnaphthalene was also reduced to a cyclic hydrocarbon (Rogers, 1991).

The process mainly involves chlorine stripping. In treatment of chlorinated aromatic hydrocarbons the removal of chlorine atoms results in an increased concentration of lower chlorinated species (eg higher congeners are replaced by lower congeners). This is not a problem with contaminants such as PCBs. However, with constituents such as dioxins the lower congeners (eg TCDD) can have a higher toxicity than the more highly chlorinated congeners (eg OCDD). Therefore the process must be monitored to ensure that the reaction continues to completion.

In the case of treatment of PCBs and PCB contaminated oils, treatment will typically reduce the PCBs to less than detection (0.1 mg/kg total PCBs for the lower congeners, and 0.01 mg/kg for the higher congeners) if sufficient reaction time is allowed. Given that the process is a batch operation, it is possible to allow the reaction to proceed until the required level of destruction has been confirmed.

5.2.3 Considerations in the Application of the Technology

The BCD process is largely contained and the emission of gases is very small compared with other combustion systems. For example, air emissions associated with treating a contaminated soil containing 5000 mg/kg of PCP have been reported as follows (Carlisle, 1994a):

- $<10 \ \mu g/m^3 PCP;$ and
- $<100 \text{ ng/m}^3$ dioxins (as TCDD).

Similar emissions have been reported associated with the treatment of other organochlorines such as PCBs. The potential to form dioxins and furans in the BCD process is low, particularly when the system is operating under an inert atmosphere. In addition, any dioxins formed in the process should be subsequently dechlorinated in the system. As such, the risk associated with emissions from the normal operation of the system is relatively low, although in general the destruction efficiencies are not as high as can be achieved by high temperature combustion systems. However, as the system is operated on a batch basis, the treatment efficiency can be controlled by extending the time for treatment as desired. As part of trials of the BCD process in the US, Battelle have completed detailed mass balances across the system, adequately accounting for all reagents and reaction products (Alleman, 1995).

If volatile solvents are present (such as occurs with pesticides), then preferably these should be removed by distillation and the resulting sludge slurried in oil for treatment.

The effect and therefore limitation of treating wastes containing volatile solvents is a reduction in boiling point of the BCD oil; high concentrations of solvents will reduce the boiling point and not allow the desired operating temperature to be achieved. As the system operates under reflux conditions, some solvent (including volatile chlorinated organic material) can be accepted for treatment.

Risk associated with process upset is considered to be low. The main concern would be with regard to air ingress which could result in auto ignition of the oil phase and an uncontrolled emission to air. The provision of a nitrogen atmosphere over the reactor is designed to ensure that this cannot occur. The occurrence of a fire in 1995 at the Victorian BCD facility operated by Technosafe was apparently the result of operation of a storage vessel without a nitrogen blanket (see below).

The BCD process is not favoured for treating large volumes of aqueous media (including wet sludges) because of the cost of evaporating the water. This restriction also applies when the waste material is pre-processed by a thermal desorption system as again energy is required to dry the waste. This is discussed further in Section 5.3.

5.2.4 Treatment of Capacitors

Direct treatment of capacitors containing PCBs by the BCD process is not appropriate because they contain aluminium and under the alkaline conditions of the BCD process hydrogen is evolved. Solvent extraction of shredded capacitors has been proposed. However, a large number of repeated extractions (eg 30 sequences) is required to obtain residual PCB concentrations which are suitable for landfill disposal (eg < 50 mg/kg) (Krynen, 1994b). On this basis, various proponents of the BCD technology have sought to develop alternative processes.

BCD Technologies have developed a pre-treatment step to avoid this problem (Krynen, 1994b,c). They shred the capacitor and treat the shredded material with sodium hydroxide at ambient temperature. This allows hydrogen to be generated and vented to the atmosphere at ambient temperature and avoids the higher temperature and increased explosion potential of the BCD process. The material is then treated in the normal BCD process.

BCD Technologies received an amendment to their license in September 1994 which allows them to treat capacitors containing PCBs in commercial quantities. As a result, a treatment plant was constructed and commissioned and is now in operation (Krynen, 1995).

5.2.5 Experience and Availability in Australia

Three proponents of the BCD technology are ADI Limited, BCD Technologies (Brisbane) and Technosafe (Melbourne). As originally established the licence status of each group was as follows:

- Technosafe was licensed by the BCD Group (patent holder) for treatment of PCB liquids and soils in Australia;
- BCD Technologies was only licensed for the treatment of liquids in Australia; and
- ADI held a BCD licence for Europe but was required to enter into a sublicence agreement if they wished to apply the technology in Australia.

The BCD licence for each group has recently been renegotiated such that each group is now able to directly apply the BCD technology to liquids and solids in Australia. While the licences now allow a number of groups to treat soils and other solids in Australia, in practice the facilities currently available are limited to the treatment of liquids and contaminated equipment.

The status of development and application of the BCD process by each of the proponents in Australia is outlined as follows:

Technosafe:

Technosafe have re-established a BCD facility in Melbourne following a fire in 1995 which rendered the original unit inoperable (Carlisle, 1995). The fire damaged the treatment system and building. It is understood that the fire resulted from a combination of factors (Carlisle, 1995). The nitrogen blanket was in place over the reactor, however, on discharge of hot oil into a storage vessel without an adequate nitrogen blanket, the fire occurred in the storage vessel. The auto ignition point of the hot oil was lower than expected and was exceeded. The new unit has received approval from the Victorian Environmental Protection Authority (EPAV) (February, 1997) and Technosafe are again operating on a commercial basis, focussing on PCB contaminated oils, transformers and capacitors.

A licence was issued to Technosafe for a fixed PCB liquids treatment facility for treatment of liquids containing up to 2% PCBs and soils. However, at this stage, Technosafe are focussing on the treatment of PCB oils and equipment, rather than soil.

BCD Technologies:

The BCD process is in operation in Brisbane (BCD Technologies) (Krynen, 1994a) for the treatment of liquids. Regulatory approvals for the Brisbane BCD facility extend to the treatment of liquid PCBs and a range of halogenated pesticides, and the use of the BCD plant on a portable basis (eg relocated and used on site) (Krynen, 1994b). A second plant for the treatment of organic liquids has been constructed in Brisbane in order to meet market demand. The new plant has a treatment capacity of 2500 tonnes per annum (Krynen, 1995).

While the BCD Technologies plant is capable of and licensed to treat organochlorine pesticide wastes, to date this has only been a limited component of the plant throughput. The treatment of pesticide wastes and derivatives of these contaminants require the fitting

of additional odour control processes, which interrupt the treatment of PCB wastes (Krynen, 1996).

The new facility being established by BCD Technologies will have improved odour control and hence the capability of the unit to treat pesticide wastes will be enhanced. The BCD process should be capable of treating mixed pesticide wastes, eg. DDT and arsenic mixtures, however arsenic would remain in the process residue and amendments to licence conditions may be required to handle the arsenic waste generated. To date mixed pesticide wastes have not been treated in significant quantities in the Australian BCD facilities (Krynen, 1997).

BCD Technologies reports that it is currently treating capacitors containing PCB liquids at the rate of about 1 tonne per day but it hopes to significantly increase this rate. BCD are also in the process of developing an alternative capacitor treatment process. The existing market demand for treatment of PCB contaminated materials is sufficient to ensure full utilisation of the current facilities.

ADI Limited:

Until recently, ADI Limited only held a BCD licence in Europe and had to operate in Australasia via a sub-licence. As part of renegotiation of the licence with the BCD Group, ADI has been granted an unrestricted licence, allowing for the treatment of soils and liquids in Australia. As part of the licence renegotiation, ADI and the BCD Group reached a commercial resolution with respect to the use of the Soil Thermal Treatment Process (STTP) (the BCD variant developed by ADI) in Australia and New Zealand and will now jointly promote the BCD process.

While much of ADI's attention is focused on the treatment of soils and other solid wastes it also has a capability to treat liquid wastes. ADI has spent considerable effort developing in-house expertise in the BCD process and further modifying and refining the process. Through its work on the BCD process, ADI has developed the STTP which is a new process. STTP is outlined in detail in Section 5.4.

ADI, in conjunction with Institute of Environmental Science & Research Limited, NZ (ESR), has demonstrated the treatment of PCP and dioxin contaminated soil using the BCD/STTP process in New Zealand. The trial was conducted on behalf of the Ministry for the Environment and the Timber Industry Environment Council. A 60 kg/hour continuous thermal desorption unit was used to treat PCP and dioxin contaminated soil from a timber facility. The process achieved <20 ppb PCP and <1 ppb dioxin (TE) in the treated soil, confirming the ability to treat contaminated soils in a single stage process. The report covering this work is expected to be publicly available in September, 1997 (Truong, 1997).

ADI is also conducting treatability trials in New Zealand for chlorinated pesticides (eg. DDT and dieldrin from pesticide collections) using a liquid BCD treatment plant. The

plant incorporates a 300 L batch reactor and the trials are expected to be completed by the end of August. The trials also address treatment of solid OCP wastes (eg powders).

ADI has submitted several proposals to apply the BCD process in Australia, however, to date no trials have been undertaken (Coniglio, 1997).

Further information regarding the application of the BCD process in conjunction with thermal desorption in the region is outlined in the following section. At this stage, the commercial use of the BCD process in Australia is limited to treatment of organic liquids and PCB contaminated equipment.

5.3 Thermal Desorption Prior to BCD Treatment

5.3.1 Technology Description

When contaminated soil is treated directly by the BCD process, the resulting soil is likely to be oily and disposal options may be limited. For example, the soil may require disposal in a secure landfill.

To avoid this problem, some suppliers of the BCD process now propose the use of a thermal desorption unit (TDU) to remove these contaminants, to concentrate them into a liquid phase for separate treatment by the BCD process (Shieh, 1994 and Tozer, 1994). As such, the soil is not treated directly by the BCD process and the BCD reagents (including alkali and hydrocarbons) are not added directly to the soil. This avoids the problem of residual hydrocarbons in the soil. However, it does rely on the thermal desorption unit to provide adequate removal of contaminants without the chemical reaction inherent in the BCD process. One such thermal desorption system is the "Therm-O-Detox" System which has been developed by ETG Environmental Inc (ETG). This system, and thermal desorption in general, is discussed further in Chapter 20. Thermal desorption has been used in conjunction with the BCD process on a commercial basis in the United States.

Thermal desorption can be applied to soil directly without addition of reagents. However, a patented variation involves the addition of sodium bicarbonate to the soil to enhance the efficiency of desorption and reduce the operating temperature of the desorber. The sodium bicarbonate will not necessarily increase the dechlorination of the chlorinated soil constituents. In the case of PCBs for example, BCD Technologies advises that with the addition of sodium bicarbonate some 95% of the PCBs are volatilised and 5% are dechlorinated (Krynen, 1994b). In the case of constituents such as pentachlorophenol, the proportion dechlorinated in the thermal desorber is likely to be higher (eg 50%). Thermal desorption variants are discussed further in Section 5.4.

As part of its further development of the BCD process, ADI has developed a variation on the BCD process, referred to as STTP (refer Section 5.4). This process can achieve dechlorination of contaminants in soil within the thermal desorption unit. Some recycling of the vapour stream may be required to achieve the necessary destruction efficiency, depending on the contaminant. The ability to effect treatment of contaminated soil in a single stage process is expected to result in significant cost savings (Coniglio, 1997). A brief overview of recent trials of this process is presented in Section 5.2.

A complete TDU-BCD process is shown in Figure 5.1.

5.3.2 Performance

As an example of the application of the thermal desorption system, in late 1992 ETG demonstrated the medium temperature thermal desorption (MTTD)/BCD technology using the Therm-O-Detox system at a Koppers site in Morrisville, North Carolina under the Superfund Innovation Technology Evaluation (SITE) program (USEPA, 1993).

The Koppers site in Morrisville was a former wood preserving operation utilising the Cellon process, which involved pressure treatment of wood with pentachlorophenol and subsequent steaming. A pentachlorophenol contaminated rinse water was generated in the process. The rinsate from this process was placed in unlined lagoons where leaching into the soil occurred. Concentrations of pentachlorophenol in excess of 8000 mg/kg and lesser concentration of dioxins and furans were present in the soil.

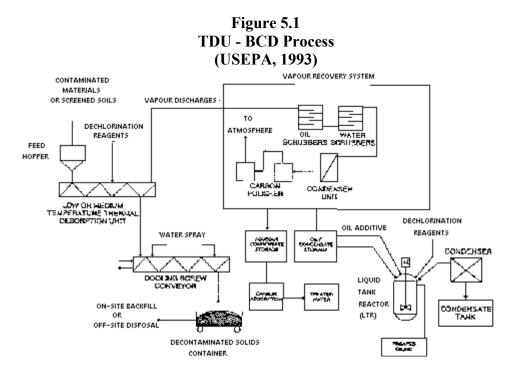
Following completion of bench-scale testing an MTTD/BCD system was mobilised, which was capable of handling 0.22 - 0.44 tonnes per hour of throughput. The equipment was placed within a portable containment pad having approximate dimensions 18 m x 24 m. Soil was excavated from the documented "hot spots" and hand screened to less than 12 mm. Contaminated soil was then placed in 210 litre drums for transport to the processing area.

Information from test runs at the Koppers site (Shieh, 1994) indicated that:

- Pentachlorophenol concentrations in the soil were reduced from 1600 8100 mg/kg, to estimated levels of 0.14 1.06 mg/kg (0.49 mg/kg average);
- OCDD and total HpCDD concentrations in soil were reduced from 15000 mg/kg and 2000 mg/kg respectively to below detection limits (approximately 20 mg/kg). Similar reductions in PCDF soil concentrations were also achieved;
- Condensed oil from the soil treatment system contained in the order of 64000 mg/L total PCDD, with approximately 600 mg/L of 2,3,7,8 TCDD. PCDF concentrations in the condensed oil were lower, in the order of 4,300 mg/L;
- Treatment of the condensed oil from the soil treatment system reduced TCDD concentrations to below the detection limits and PCDD concentrations to approximately 6 mg/L. Similar removal efficiencies were achieved for the PCDFs.

Detection limits varied from sample to sample due to dilution factors. Two other performance test runs achieved similar results.

A brief overview of recent trials by ADI of the single stage BCD soil treatment system was presented in Section 5.2. A report on the trials is expected to be released to the public in September, 1997, however we understand the trials have been successful in demonstrating the treatment of PCP and dioxin contaminated soils in a single stage process.



5.4 BCD Variants

5.4.1 BCD Plus

BCD Technologies advises that it has developed a variation of the BCD process, which it calls "BCD Plus" (Krynen, 1994b,c). In this process standard desorption equipment is used to remove the contaminants from the soil. In addition, proprietary reagents are used to convert the dechlorinated hydrocarbons into carbon dioxide and water, apparently by a catalysed combustion process which operates at a relatively low temperature. Thus, the decontaminated soil is free of oil and the inorganic salts produced by the dechlorination process remain in the treated soil. The soil can be disposed of to any landfill, assuming that the soil does not contain heavy metals. A BCD Plus plant designed to treat 50 tonnes/day of contaminated soil has been constructed by BCD Technologies. An application for regulatory approval for a BCD soil treatment system has been lodged with the Queensland Department of Environment; however, this is not being actively pursued (Krynen, 1997).

The BCD Plus process was developed, in part, to circumvent licence restrictions associated with the conventional BCD soil treatment process. Given BCD Technologies is now licensed to apply the BCD soil treatment process, the implementation of a soil treatment system is likely to follow a conventional BCD process rather than the BCD Plus process. In any case, the demand for a BCD soil treatment system has not been great and therefore the development of facilities of this kind is still dependent on the market (Krynen, 1997).

5.4.2 STTP

ADI Limited has developed a modified BCD process for the treatment of contaminated soil called STTP (Soil Thermal Treatment Process). Where the BCD Technologies process is based on a hydrodechlorination reaction, the STTP process is said to be based on a carbonisation reaction. (Patents have been lodged by ADI for this process as an alternative treatment process to the BCD process.)

The STTP reaction can be carried out in a solid phase within a thermal desorption unit or in a liquid phase in a separate reactor. The primary focus in development of the STTP process has been the treatment of contaminated soils and other solid wastes and therefore use of the STTP process in conjunction with thermal desorption.

As with the "BCD Plus" process, STTP aims to achieve a significant proportion of the carbonisation/dechlorination/decomposition within the thermal desorption unit. For some wastes the STTP system is able to achieve effective carbonisation/dechlorination/ decomposition in a single stage, obviating the need for a separate reactor to treat condensate from the thermal desorber. The ability to complete the BCD reaction in a single stage rather than a two stage process, has an obvious cost advantage when treating soils. ADI advises that the single stage STTP process has been demonstrated on a pilot scale with PCP contaminated soil, with a high destruction efficiency of the PCP within the desorber. Dioxins if present, will be desorbed in this process and will require condensation and treatment in a separate reactor (Coniglio, 1996). Alternatively, recycling a portion of the vapour stream back through the thermal desorption process has been found to provide for adequate treatment of the dioxins (Coniglio, 1997). Treatment of dioxins in condensate from PCP contaminated soil has been demonstrated to a level in excess of 99.999% (DRE).

ADI is currently proposing to use an indirectly heated thermal desorption unit with the majority of contaminant destruction occurring within the thermal desorber, followed by a reactor for treatment of condensate (only if required). This system is known as the STTP Solids System.

While the main focus of ADI's STTP work is treatment of soils, the process is capable of treating liquids. Pilot plant trails using PCB contaminated oils have demonstrated reduction in PCB concentrations from 20% to PCB-Free as defined in the PCB Management Plan (1995) ie < 2 mg/kg.

5.4.3 Considerations in the Application of the Technology

Thermal desorption places constraints on the physical form of the waste to be treated, depending on the type of thermal desorber being used.

In the case of indirectly heated rotary kilns, a range of waste types can be treated. However, a typical feed size limitation of 25 mm usually applies (Carlisle, 1994a; Tozer, 1994; Krynen, 1994a). If this size is exceeded, then the desorption can be incomplete or the desorber mechanism may be blocked (this is dependent on the desorber system). In practice, desorption can be enhanced by increasing the temperature or by adding reagents. Higher boiling point waste materials such as PCBs and chlordane may not desorb effectively unless a reagent such as sodium bicarbonate is added to the mixture.

Materials handling problems can be expected to be significant for some waste materials, such as concrete (particularly if it includes steel reinforcing), rubbers and tars. Such materials are present for example, in the hexachlorobenzene (HCB) wastes held at Botany.

Thermal desorbers currently under development by the Australian BCD licensees need to be portable in nature (able to fit in one or two shipping containers) and should be easily relocatable from site to site (Krynen, 1994b; Tozer, 1994).

The treated soil from this process is sterile, but is expected to be in a form which will permit its return to a site (Carlisle, 1994a). This is in contrast to incineration, where the soil structure is permanently changed such that landfill disposal is required.

5.4.4 Experience and Availability in Australia

The use of thermal desorption for treatment of wastes in conjunction with a liquid BCD plant has not yet received approval by the relevant regulatory authorities in Queensland. Use of thermal desorption in conjunction with a liquid BCD Plant is not currently being pursued in Victoria.

BCD Technologies (Qld) advises it has constructed a thermal desorption (rotary kiln) system and is presently pursuing licence renewal for its trial unit. To date, the demand for a BCD soil treatment facility has not been sufficiently high to make the commissioning and approval of this unit a priority compared to the treatment of PCB contaminated oil and equipment.

BCD Technologies proposes to operate the unit as a normal desorber with condensation of the off gases for treatment in the liquid BCD plant. This desorber is expected to be portable (2 shipping containers) and it should be possible to relocate this unit to other States, if appropriate licence approvals can be obtained. The proposed thermal desorption system will extend the capability of the process for treatment of a wider range of waste materials than is presently possible. Technosafe (Vic) has a licence to treat soils using the BCD process and has built a prototype thermal desorber for trial purposes. The process has not been re-established since the fire in 1995 and Technosafe advises that at this stage they are unlikely to pursue further development or approvals for this treatment process.

ADI advises that it has a thermal desorption unit under construction for use in Europe and has conducted extensive trials in Australia and New Zealand at laboratory and pilot scale. ADI has refined the BCD-thermal desorption process with the aim of applying the system to the treatment of contaminated soil both in Europe and Australasia. ADI also has experience in the field use of thermal desorption for contaminated site clean up. It has a direct fired thermal desorption unit rated at some 20 tonnes per hour available for use in Australia and New Zealand. However, because this unit is direct fired, it is not suitable for use in conjunction with the BCD process.

5.5 Summary

(a) Proponents (in Australia)

BCD Technologies (Brisbane).

Technosafe Waste Disposal (Melbourne).

ADI Limited

(b) Wastes Applicable

Low volatility organic liquids and high volatility organic liquids (following evaporation of volatile solvents) (BCD reactor only).

Soils, sludges, irregular larger inert solids (following size reduction) and semi-solid materials (BCD in conjunction with thermal desorption or solvent extraction).

PCB contaminated transformers (BCD in conjunction with solvent extraction).

PCB contaminated capacitors (BCD in conjunction with size reduction and alkaline pretreatment, or solvent extraction (although a large number extractions is required)).

(c) Contaminants Applicable

All scheduled compounds.

(d) Status

Commercially available in Queensland for low volatility liquids and PCB contaminated transformers and capacitors. Victorian treatment facility is back in service following the 1995 fire, allowing treatment of PCB contaminated oils, transformers and capacitors. The

technology is commercially available overseas for treatment of solids. ADI does not yet have a unit commercially available, although have successfully trialed treatment of contaminated soil.

(e) Timing for Commercialisation in Australia

Treatment capacity currently available for liquids. Potential to be commercially available for soils and other solids within 6 to 12 months, depending on regulatory approvals and market pressures. Development of a soil treatment capability in Australia is more likely to occur over a period of 1 to 5 years, although 6 to 12 months would be possible.

(f) Cost (example only)

\$250 to \$400/tonne for contaminated soil (pending).

\$1000/tonne for lower concentration PCB contaminated oils, higher for high concentration oils.

\$4.50 to \$5/kg for larger capacitors, up to \$12/kg for smaller lighting capacitors.

Waste holders state that costs have been increasing whereas the waste treatment groups state costs for treatment of liquids have been reduced, although the cost of treating capacitors has increased.

(g) Safety/Environmental Risk

Emissions associated with treating 5000 mg/kg PCP in soil by BCD have been reported as $< 10 \ \mu g/m^3$ (organochlorine compounds eg PCP, PCB) and $< 100 \ ng/m^3$ (TCDD eq). Potential to form dioxins and furans is low as the system operates under an inert atmosphere and dioxins should be dechlorinated by the process. If dioxins are to be treated, there is potential for higher chlorinated congeners (OCDD) to be dechlorinated to form more toxic lesser chlorinated congeners (TCDD) and the reaction conditions should be selected to ensure the reaction goes to completion. System operates at only moderately elevated temperatures, therefore any accidental release should be able to be contained with appropriate precautions. Exclusion of air from the BCD process is important to avoid auto-ignition of hot oil used in the process.

Some associated processes such as the alkaline pretreatment of capacitors and solvent extraction carry with them a significant fire and explosion risk, and hence appropriate precautions must be taken.

(h) Non-technical Impediments

The BCD process is generally not regarded adversely by the community.

(i) Preferred Mode of Implementation

Currently established as small centralised, liquid only, BCD reactors in Brisbane and Melbourne. The Brisbane unit is portable. Any soils treatment system would most likely be a mobile unit.

(j) Limitations

Uneconomical to treat large volumes of aqueous wastes. While sufficient for most purposes, the destruction efficiencies achievable are low compared with incineration systems. Salt build-up when treating concentrated chlorinated wastes can halt the reaction prematurely, requiring the waste to be pre-diluted to attain the required destruction efficiencies. Treatment efficiency of soils is limited by the efficiency of the thermal desorption process.

The BCD process is not adversely affected by the presence of arsenic or other contaminants in mixed pesticide wastes, although treatment of such material has been limited by restrictions on the disposal of the arsenic containing residue. Energy costs for the treatment of pesticide wastes may be higher, given the solvents will need to be distilled from the mixture in order to reach the operational temperature.

APPENDIX 3 - Plasma Arc Technologies

CMPS&F - Environment Australia Appropriate technologies for the treatment of scheduled wastes Review Report Number 4 - November 1997

13. PLASMA ARC SYSTEMS

- <u>13.1 General</u>
- 13.2 PACT Process
- <u>13.3 PLASCON</u>
- <u>13.4 STARTECH</u>

13.1 General

Plasma arc treatment is a high energy technology able to treat a range of scheduled wastes. In plasma arc treatment a thermal plasma field is created by directing an electric current through a low pressure gas stream. Plasma arc fields can reach 5000 to 15000°C. The intense high temperature zone can be used to dissociate the waste into its atomic elements by injecting the waste into the plasma, or by using the plasma arc as a heat source for combustion or pyrolysis.

The plasma arc processes considered in this review include:

- PACT (Plasma Arc Centrifugal Treatment)
- PLASCON (In-Flight Plasma Arc System)
- <u>STARTECH (Plasma-electric waste converter)</u>

13.2 PACT Process

13.2.1 Technology Description

The Plasma Arc Centrifugal Treatment (PACT) process, developed by Retech (USEPA, 1992 and Thomas, 1994), uses heat generated from a plasma torch to melt and vitrify solid feed material. Organic components are vaporised and decomposed by the intense heat of the plasma and are ionised by the air used as the plasma gas, before passing to the off-gas treatment system. Metal-bearing solids are vitrified into a monolithic non-leachable mass.

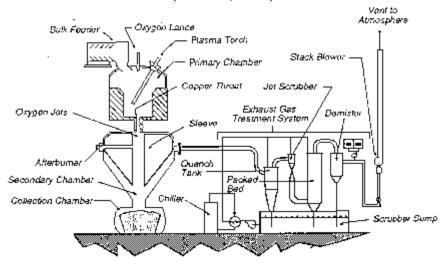
The PACT system comprises thermal treatment and exhaust gas treatment systems, shown conceptually in Figure 13.1. The thermal treatment system consists of:

- a feeder;
- a primary chamber;
- a plasma torch;
- an afterburner;
- a secondary chamber; and
- a collection chamber.

The exhaust gas treatment system consists of:

- a quench tank;
- a jet scrubber;
- a packed-bed scrubber;
- a demister; and
- a stack blower.

Figure 13.1 Plasma Arc Centrifugal Treatment System (USEPA, 1992)



The waste is initially loaded manually, from sealed containers, into a screw feeder. The waste is fed uniformly and continuously into the centrifugal reactor through a chute connecting the feeder to the primary chamber, which is a rotating tub with a central orifice.

A copper throat, at the bottom of the primary chamber, is used to strike the arc of the plasma torch. The torch is then moved slowly up and down the side of the primary chamber during heat up. Feeding the waste material begins once the primary chamber's temperature is greater than 1100°C and the secondary chambers temperature is greater than 900°C. Solid material is retained in the tub by centrifugal force. The primary chamber walls have an inner shell with a water jacket welded between. A water/corrosion inhibitor cooling stream circulates between the shell and the jacket.

The plasma torch uses electrical discharges to add energy to plasma torch gases in order to increase the gas temperature beyond that normally attainable by chemical reaction. The plasma torch produces a transferred arc that directly contacts a conducting portion (copper throat) of the centrifugal reactor. The heat generated by the plasma torch brings the waste material to temperatures sufficient to melt soil (typically in the order of 1650°C). The waste is melted by this extreme heat, incorporating any inorganic and metal components into a stable material. Organic components are volatilised by the heat of the plasma gas. Oxygen may also be added, via an oxygen lance in the primary chamber, to enhance combustion of organics.

The torch runs on direct current provided by a 3-phase power supply and is cooled by a high velocity flow of distilled water.

After the feed material adjacent to the copper throat is heated to the conducting temperature, the torch is moved slowly to heat more of the waste on the bottom of the reactor and eventually the sidewall. As the torch is moved away from the centre of the reactor, the rotation is slowed to allow the molten waste to run towards the centre, where it begins to solidify. This is continued until the entire primary chamber has been treated by the torch.

Once the complete primary chamber has been treated, the torch is then used to melt the mass of waste at the copper throat. When the mass is melted, the reactor spin rate is slowed to allow the pool to move inward and the melted waste to pour out of the bottom of the reactor through the throat, past a natural gas afterburner. The afterburner does not operate during the pouring process.

The afterburner, located just downstream of the primary chamber, provides an additional heat input beyond that supplied by the plasma torch to combust products (typically short chain organics) of incomplete combustion (PICs). The afterburner operates on a natural gas flame. The use of a secondary combustion chamber was required by the USEPA (as with high temperature incineration) to ensure complete combustion and destruction, particularly of dioxins and similar components. The organics that are volatilised and oxidised (or combusted) are drawn off to the gas treatment system.

A camera port in the secondary chamber allows observation of the gases and slag exiting the throat. If needed, oxygen may be added from oxygen jets located in the secondary chamber to enhance combustion of organics. The secondary chamber walls have 7.52 cm of refractory lining to abate heat loss and protect the steel walls. These walls also form a jacketed vessel with cooling water circulating between them to maintain a safe operating temperature.

The molten mass falls from the secondary chamber into a heavy pig mould located in the collection chamber. The collection chamber is a cylindrically shaped, water-cooled, jacketed vessel. One end is closed off and the other end has a hinged door, where the pig moulds are loaded and unloaded.

Effluent gas treatment equipment is designed to suit requirements of the feed material. A typical gas treatment system can comprise a quench tank, a jet scrubber, a packed-bed scrubber, and a demister.

A mildly caustic scrubber solution (pH maintained at 8.5) is used in the quench tank, jet scrubber, and packed-bed scrubber. The scrubber sump is equipped with a chiller to cool the scrubber water circulating through the exhaust gas treatment equipment, so that all the moisture can be removed from the exhaust gases. The chilled scrubber water proceeds first to the quench tank, where it cools the exhaust gas stream from approximately 540°C to 4°C. From the quench tank, the scrubber water passes to a jet scrubber, which is designed to remove particulates and acid gases. A counter-flow packed bed scrubber provides additional removal of acid gases. A demister then removes moisture droplets entrained in the flow.

The system is hermetically sealed and operated below atmospheric pressure to prevent leakage of process gases. Pressure relief valves connected to a closed surge tank provide relief if gas pressures in the furnace exceed safe levels. Vented gas is held in the tank and recycled into the furnace.

The clean gases are emitted to the atmosphere through an exhaust stack. A stack blower at the exhaust stack maintains a negative pressure in the reactor system, preventing any leakage.

The PACT process has been developed by Retech and is available in a range of sizes, relating to the diameter of the primary chamber in feet. ie. 2 ft, 4 ft, 6 ft and 8 ft. Retech's licensee in Europe is MGC Plasma AG of Basel, Switzerland who is now wholly owned by Moser Glaser AG a large Swiss transformer manufacturer (Zissermann, 1996).

The 6 ft PACT is undergoing extensive evaluation at the US Department of Energy's (DOE's) Western Environmental Technology Office in Butte, Montana. MSE Inc is the engineering company involved in the evaluation.

MGC Plasma AG has erected and trialed an 8 ft diameter unit which in Europe has the trade name "Plasmox". The major components of this unit, such as the primary and secondary chambers and the control panel, have been procured by MGC Plasma from Retech, but much of the equipment (particularly the gas cleaning equipment) was designed and sourced in Europe. An 8 ft unit has also been sold to the German Army for the clean-up of soil contaminated with chemical warfare agents, many of which are arsenic compounds. The 2 ft and 4 ft units can be made readily relocatable by being designed to fit within standard container-sized modules. The 6 ft and 8 ft units are more suited to a fixed installation.

13.2.2 Performance

The results show that:

- The technology can process media contaminated with both organic scheduled compounds and inorganic (heavy metal) compounds which are incorporated into a non-leachable material during treatment.
- The destruction and removal efficiency (DRE) of organic compounds is greater than 99.99%.
- Volatile metals and products of incomplete combustion (PIC) can be generated and may need to be removed by an appropriate scrubber. If required, disposal of the scrubbing water would add additional cost.

The process has been demonstrated successfully under the USEPA SITE program, with the treatment of a mixture of 28000 mg/kg zinc oxide and 1000 mg/kg HCB in diesel oil. destruction and removal efficiency (DRE) exceeded 99.996% (HCB was not detected in the stack gas) and the treated material met TCLP requirements. Particulate emissions in the test did not comply with the regulatory standard and the off-gas treatment system was to be modified accordingly. Particulate emissions from a PACT system in Muttenz were well within the US regulations. Dioxins were not detected in the stack gas (USEPA, 1992).

13.2.3 Considerations in the Application of the Technology

The PACT system has the ability to accept a wide range of waste materials, including large solid articles, and as such can be regarded as a flexible treatment system. The system can be applied to wastes containing both organics and heavy metals. In this regard the process has been referred to as "omnivorous".

Given the large thermal mass of the system, the risk associated with short term upset is likely to be low. Similar to in-flight plasma systems, the volume of gases produced in the process are much less than in incineration systems. It has been calculated that for a highly chlorinated waste such as hexachlorobenzene, PACT should produce gas volumes less than 2% of the volume of an incinerator of equivalent capacity (Selinger, 1995). If secondary combustion is required, this can add to the gas volume.

Given that the system can operate under pyrolytic conditions and a reducing atmosphere, dioxin formation in the primary chamber can be avoided. However, as it is usual to follow primary combustion with a secondary combustion step, there is a potential for dioxins to form and the provisions normally applied to incineration to minimise dioxin formation should also be applied to this system. Given the total air emission volumes are less than for conventional combustion processes, the potential impact of emissions is expected to be lower.

Treated soils and other materials from this process are generally converted into ash and as such can be returned to the site.

The PACT system can be expected to have a relatively high capital cost, and operating cost (\$4000 - \$8000 per tonne). However, the cost will be dependent on the scale of operation, and because the PACT process has the capability of directly treating diverse

waste types, it can avoid the preparation or pretreatment costs which may otherwise be necessary for treatment by other processes.

13.2.4 Experience and Availability in Australia

While not established in Australia, the PACT system has been developed to a commercial scale for use overseas, and draws on established principles of combustion engineering. For the purposes of this review it is considered to be a developed process, although the requirement for trials means several years would be required for establishment of a full scale system in Australia. The implementation of the PACT process is linked to the limited number of major hazardous waste projects in Australia being progressed. For example, implementation of the PACT process has largely been discussed in terms of application to the treatment of HCB waste held by ICI at Botany (although a decision regarding treatment of this waste is yet to be made).

PACT technology has been selected for the clean-up of Pit 9 at the US DOE's Idaho National Engineering Laboratory. Pit 9 contains organic, inorganic and radioactive wastes. The consortium to undertake the work includes Lockheed Martin and MSE Inc. (Zissermann, 1996).

13.2.5 Summary

(a) Proponents (in Australia)

Waste Service NSW (Sydney).

(b) Wastes Applicable

All waste types, although concentrated wastes preferred on economic grounds.

(c) Contaminants Applicable

All scheduled compounds.

(d) Status

The PACT system is not yet established in Australia, however, it is operational on a commercial scale in Europe and in the US.

(e) Timing for Commercialisation in Australia

A commercial scale plant has been established in Europe and a similar plant is available in the USA. Establishment of the process within Australia could be achieved within a short time frame, if commercial viability was established and prompt regulatory approvals were obtained. Trials on Australian wastes were proposed for evaluation in the USA in 1995, however, these have been delayed (Zissermann, 1996). Establishment of the process in Australia will depend on the waste volume requiring treatment and the available competing processes. In particular, implementation of the PACT process is likely to be dependent in its selection for use in one of the few major waste treatment projects in Australia that could justify the capital expense associated with implementation in Australia.

(f) Cost (example only)

Approximately \$4,000-\$8,000/tonne

(g) Safety/Environmental Risk

Operational experience in Europe has not identified specific problems. The absence of combustion gases means that gaseous emissions are much smaller than for high temperature incineration. A surge tank is provided to contain any uncontrolled release of gases from the treatment chamber. The use of mechanical seals and operation of the unit at slight negative pressures should ensure there are no significant fugitive emissions. The vitrified nature of the slag greatly reduces any potential leaching of metals or other residual contaminants. The available data indicates compliance with regulatory requirements regarding air emissions can be achieved and dioxins were not detected in the stack gas during trials under the USEPA SITE program.

(h) Non-technical Impediments

Information on this issue was not provided by the proponent. While the process includes some elements of combustion, it is likely to be viewed as sufficiently different from high temperature incineration by the public.

(i) Preferred Mode of Implementation

A centralised system is preferred. However, the PACT process is transportable in smaller plant sizes ie. a 2 ft diameter PACT system will fit into 2 x 20 ft long standard ISO shipping containers.

(j) Limitations

Removal of volatile metals and particulates which are formed from inorganic components of the waste (such as drums) may require removal by a conventional gas scrubber or gas cleaning system. Provision of either of these additional treatment steps may in turn add additional costs to this treatment process.

The PACT system is expected to have a relatively high capital and high operating cost, however, the final cost of treatment will depend on the overall scale of the operation. As the process is able to directly treat diverse waste types, pretreatment is not usually required and cost savings may result.

13.3 PLASCON

13.3.1 Technology Description

CSIRO and Siddons Ramset Limited have developed PLASCON, an in-flight plasma arc system. This technology was designed to treat process wastes from chemical manufacturing by using a high temperature electric arc plasma destruction technique (Hawkes, 1994a). SRL Plasma Limited (a division of Siddons Ramset Limited) has the full commercial rights to this process.

In the PLASCON system a liquid or gaseous waste stream together with argon is injected directly into a plasma arc, which provides plasma/waste mixing temperatures in excess of 3000°C. At these temperatures organic material is pyrolysed. That is, the organics in the waste dissociate into elemental ions and atoms and recombine in the cooler area of the reaction chamber prior to a rapid, alkaline quench to form simple molecules. The resulting end products include gases consisting of argon, carbon dioxide and water vapour and an aqueous solution of inorganic sodium salts (including sodium chloride, sodium bicarbonate and sodium fluoride) (Frost, 1995). Further treatment of the end product is not required.

In the order of 1 to 3 tonnes/day of waste can be treated by a 150 kW unit. The residence time of the waste in the reaction chamber is very short (approximately 20-50 milliseconds) since such high operational temperatures are utilised. This results in a small process inventory, with less than 0.5 g of waste being destroyed at any instant (Frost, 1995).

Electricity is the main energy input into the process. A 150 kW PLASCON unit requires 1000 to 3000 kWh of electricity per tonne of waste and 250 to 400 kW of cooling duty. Cooling is provided by a closed loop water circuit (Frost, 1995).

Plasma technology has been described as a "robust" technology which can be readily tailored to suit a specific application. This is accomplished by specifically designed front and back ends (ie. pretreatment systems and gas treatment systems) to suit a particular waste type (Hawkes, 1995).

The waste stream to be treated must be a liquid or a gas, however, any form of preprocessing which will produce a liquid or a gas can be used upstream of the PLASCON process unit. For example, contaminated soil and very viscous liquids or sludges thicker than 30 to 40 weight motor oil cannot be processed by the system without pretreatment (Frost, 1995). In this regard SRL Plasma has adopted a different approach to that adopted by many technology vendors. Processes such as BCD and Eco Logic have been promoted in a configuration that includes pretreatment for specific wastes. The focus of SRL Plasma is to develop solutions and license their technology to other parties. Only in limited cases will SRL Plasma operate their own plant. SRL Plasma suggest that a plant tailored to a specific application can be designed, built and be in operation in a period of about six months (Hawkes, 1995).

On this basis, while PLASCON is not currently available in a configuration capable of treating a range of waste types (eg. contaminated soil, capacitors, etc.) PLASCON, in conjunction with appropriate preprocessing (eg. thermal desorption) could treat a wide range of wastes.

It can be expected that the unit will be implemented as a relocatable centralised facility rather than a portable system which is moved from site to site (Hawkes, 1994 b).

The PLASCON unit is shown schematically in Figure 13.2.

13.3.2 Performance

Test samples of PCBs made up from an Askarel type oil containing Aroclor 1260 and trichlorobenzenes in the ratio of 65:35 which were treated in a bench scale plasma arc unit showed dioxin levels in scrubber water and stack gases in the part per trillion range. The Aroclor 1260 mainly contains hexachlorinated (42%) and heptachlorinated (38%) biphenyls. DREs in the test ranged from six to eight nines confirming in-flight plasma systems can achieve very high destruction efficiencies. Dioxin formation is generally avoided in in-flight systems such as PLASCON, because the process involves pyrolysis rather than combustion (Frost, 1994).

The PLASCON process has been in operation since 1992 at Nufarm Limited. The Nufarm plant, used in-line for treating process wastes, is approved by the EPAV and is commercially viable.

13.3.3 Considerations in the Application of the Technology

Plasma arc treatment involves a much lower quantity of combustion gases than incineration, thus reducing the risk associated with the discharge of the emissions to air and the cost of air pollution control. Given the very low process inventory in the PLASCON system (ie less than 1 g in the reaction chamber), the risk associated with release of partially treated wastes following a process failure is very low (Hawkes, 1994a).

Significantly reduced emissions count in favour of plasma arc systems, and this process is not associated with the level of community concern which accompanies incineration systems.

In-flight plasma arc treatment processes are applicable for liquid and gaseous wastes, and in general are not applicable to solid wastes unless there is some form of pretreatment undertaken. As such, in-flight plasma arc systems are usually discussed in the context of direct treatment of liquid or gaseous wastes. Plasma arc treatment can be linked with thermal desorption, and would have the potential to provide relatively complete destruction of contaminants in solid and semi-solid materials.

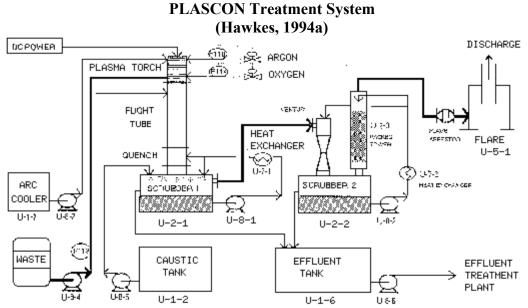


Figure 13.2

13.3.4 Experience and Availability in Australia

PLASCON has, to date, treated wastes including (Frost, 1995):

- Halon 1211; •
- CFC 11, CFC 12; •
- **HCFC 22;** ٠
- Askarel (65% PCB, 35% trichlorobenzene);
- Nufarm waste (40% chlorophenols, 40% chloropentoxy acetates, 20% toluene).

SRL Plasma is currently focusing on expanding its operating experience to a wide range of scheduled wastes.

The PLASCON system is operating at Nufarm, a herbicide manufacturing works in Laverton, Victoria. This is the first Australian commercial PLASCON facility. It has been in operation since early 1992 and was licensed by the EPAV in 1993. The plant operating currently at Nufarm is a 150 kW system. This facility is being used to treat totally organic waste containing a variety of organochlorine compounds, on a small throughput basis. Typically, the waste averages 30% w/w of chlorine. A second PLASCON unit has been commissioned to cope with the increased plant throughput (200 kW system).

The waste treated by PLASCON at Nufarm is moderately viscous, with a high concentration of chlorinated organics, and a solids content of 40%. Extensive research and development including several modifications to the Nufarm plant has resulted in a PLASCON unit that can reliably treat the waste. SRL Plasma indicates that the development of the plant at Nufarm has meant that it has tackled and solved many

difficult problems that would streamline the development of new applications (Hawkes, 1995).

The PLASCON system is being used to treat the Nufarm waste on a continuous or semicontinuous basis.

A new installation for Ozone Depleting Substances ¹ destruction using PLASCON technology has been constructed. The facility is owned and operated by SRL Plasma for the purpose of destroying the waste Halon and CFC stockpile held by the Department of Administrative Services Centre for Environmental Management (DASCEM), which administers the National Halon Bank on behalf of the Federal Government. This unit has destroyed significant quantity of Halon wastes and is currently operating on a two shift basis. Within a short period of time SRL Plasma Limited expect to operate an "unmanned" third shift which will have interlocks within the process to ensure safe shutdown in the event of any system failure.

SRL Plasma has also reached an agreement to provide the PLASCON technology for use by BCD Technologies in Brisbane. It is understood that the PLASCON unit is currently under construction and will be commissioned in mid-1997 (Krynen, 1997). A six month trial and demonstration licence has been obtained for the system. BCD Technologies view the PLASCON systems as an important adjunct to their established waste treatment capabilities using the BCD process. In particular, BCD Technologies intends to make use of the PLASCON unit for the treatment of high strength wastes such as pure PCB liquids. Such wastes are not well suited to treatment using the BCD process (although the BCD process is well suited to the treatment of PCB contaminated transformer oils). Currently BCD Technologies is treating small quantities of pure PCB liquids by blending with dilute, PCB contaminated oils. BCD Technologies is also considering linking the PLASCON unit with a thermal desorber for the treatment of a range of solid and semisolid waste streams. This should result in a significant new treatment capacity for scheduled wastes in Australia.

BCD Technologies had delayed the decision to implement a technology such as PLASCON, based on the assumption that the Eco Logic facility in Western Australia would have sufficient capacity to meet the requirement for treatment of high strength PCB wastes in Australia. The decision by BCD Technologies to purchase and implement the PLASCON technology for the treatment of PCB wastes reflects the failure of the Eco Logic process to live up to earlier claims regarding treatment capability and capacity.

PLASCON technology is available for both in-line and stockpile applications. PLASCON markets are currently being pursued both domestically and internationally.

13.3.5 Summary

(a) Proponents (in Australia)

SRL Plasma Limited (a division of Siddons Ramset Limited). In addition, BCD Technologies has purchased a PLASCON unit from SRL Plasma which will be available for treating a range of wastes.

(b) Wastes Applicable

Liquid waste streams (either organic or aqueous) of any concentration can be treated but it is most cost effective to treat concentrated wastes. Solids can be treated if in the form of a pumpable fine slurry. The system can be linked with thermal desorption or other pretreatment methods to treat a wide range of solids and sludges. Special wastes such as capacitors and transformers can be treated after pretreatment to remove solids.

(c) Contaminants Applicable

All scheduled compounds.

(d) Status

Commercially available and operational in Australia both as in-line and stand alone configuration. A PLASCON system is currently operating at Nufarm in Laverton, Victoria. A second PLASCON system is currently being used to destroy stockpiled CFCs and Halons. A PLASCON system will shortly be available through BCD Technologies for the treatment of a range of wastes, including high strength PCB wastes.

(e) Timing for Commercialisation in Australia

Currently available as an in-line system. The PLASCON unit purchased by BCD Technologies is expected to be commissioned in the second half of 1997.

(f) Cost (example only)

Operating costs including labour vary depending on the work to be treated and the location of the site. These costs are estimated to be under \$3000/tonne but typically range from \$1500 - \$2000/tonne. SRL Plasma indicate (Hawkes, 1994a) that there is a considerable range of cost depending upon factors such as:

- waste feed molecular structure and weight;
- electricity costs;
- argon and oxygen costs;
- geographic location and site specific issues;
- caustic costs; and
- the required emission limits.

SRL Plasma indicate that the economics of the process are not sensitive to chlorine content of the waste (Hawkes, 1995).

(g) Safety/Environmental Risk

A significant advantage of the PLASCON system is the low process inventory. The process is electrically powered and can be shut down or started up in seconds. Process control interlocks are provided to prevent the release of incompletely treated waste, in the case of power failure or similar process upset. Other safety hazards relate to the storage of hazardous materials prior to treatment and the use of high temperatures. Emissions from the treatment system are limited to an emission to air containing argon, oxygen, water vapour and carbon dioxide, and a trade waste discharge containing a sodium halide salt. Dioxin formation is avoided by the use of pyrolysing conditions.

(h) Non-technical Impediments

Nil.

(i) Preferred Mode of Implementation

A centralised or relocatable unit.

(j) Limitations

Only able to treat liquids and gases. Solids can only be treated following extraction using another technology or by formation of a fine pumpable slurry.