MANAGEMENT OF TOXIC INDUSTRIAL WASTE IN SINGAPORE

1 Introduction

1.1 Wastes may be defined as materials which no longer can be used for the purposes they were intended for originally. Toxic industrial waste is waste which by their nature and quality may be potentially detrimental to human health and/or the environment and which require special management, treatment and disposal.

1.2 In view of Singapore's small land area with limited land and water resources, the siting of industries has to be carefully planned and managed. In addition, industries are required to design their manufacturing processes and provide pollution control facilities to comply with pollution control requirements on emission of air pollutants, discharge of industrial effluent, management of hazardous substances and toxic industrial waste.

1.3 There are currently several thousands of companies in Singapore which handle or use hazardous chemicals. The use of these chemicals generates a wide variety of toxic industrial waste. The main types are spent acids, spent solvents, spent etchants, waste oil and other waste sludge.

2 Strategy for Control of Toxic Industrial Waste

2.1 The key elements in Singapore's strategy to control toxic industrial waste and ensure their safe treatment and disposal are as follows:

(i) avoid generation of intractable wastes;

(ii) encourage waste minimisation;

(iii) encourage waste reuse, recovery and recycling;

(iv) regulate collection, treatment and disposal;

(v) monitor and audit collection, treatment and disposal; and

(vi) promote and support educational and training programmes.

2.2 All new industrial developments are screened by the National Environment Agency (NEA) at the planning stage. One of the key areas checked in this screening process is the generation and disposal of wastes from proposed industrial developments. NEA would approve the proposed industrial development only if the wastes generated could be safely disposed of in Singapore. This avoids the generation of intractable wastes that cannot be safely disposed of in Singapore.

2.3 In addition, NEA will require industries to use processes that minimise waste generation or facilitates the reuse, recovery and recycling of the wastes. Industries also need to incorporate measures into the design of their facilities to ensure wastes generated can be properly handled and managed. At the building plan stage, checks are made to ensure that these measures are incorporated into the design of the plants.

2.4 NEA has encouraged the setting up of specialised waste recycling, treatment, and disposal plants. There are currently close to 100 such plants in Singapore, treating and recycling a wide range of toxic industrial waste. Some of the toxic industrial waste collected and recycled by these plants for reuse are discussed in Section 5.

2.5 The setting up of specialised waste recycling, treatment and disposal plants serve to help industries, especially the smaller companies, which may generate small quantities of special wastes but find it impractical or uneconomical to install, operate and maintain a waste treatment facility because of cost, lack of expertise or space constraint.

2.6 The collection, recycling, treatment and disposal of toxic industrial waste are controlled under the Environmental Public Health Act (EPHA) and the Environmental Public Health (Toxic Industrial Waste) Regulations (EPH(TIW)Regs).

3 The Environmental Public Health (Toxic Industrial Waste) Regulations (EPH(TIW)Regs)

3.1 The control on the import, sale, supply, receipt, transport, treatment and disposal of toxic industrial waste are regulated under the EPH(TIW)Regs. Toxic industrial waste controlled under the EPH(TIW)Regs are listed in the Schedule of the Regulations as

waste streams from specific industrial activities, wastes with specified toxic components and as specific categories of wastes. The list includes spent acids, alkalis, wastes containing gallium arsenide, spent etching solutions containing copper from printed circuit board manufacturing, etc. The list is at the **Annex**.

3.2 In order to facilitate controls and proper management, the functions and responsibilities of key persons involved in handling of the toxic industrial waste are clearly delineated in the EPH(TIW)Regs. The key persons include the following:

(a) Generator of wastes
(b) Collector
(c) Carrier or transporter
(d) Driver

3.3 The generator will have to treat the wastes in an approved in-house waste treatment plant and dispose of the residues, if any, at NEA's approved landfill site. Alternatively, the generator can engage a licensed toxic industrial waste collector to collect his wastes for treatment and disposal.

3.4 A toxic industrial waste collector is a person who receives toxic industrial waste for storage, reprocessing, treatment and disposal. He is required to obtain a licence from NEA to collect specific toxic industrial waste that are listed in his licence and confine his waste storage and treatment activities to approved premises and facilities.

3.5 Written transport approval from NEA is also required for the transportation of wastes in quantities which exceed those specified in the EPH(TIW)Regs. The responsibilities of the following key persons in the transportation are clearly defined in the EPH(TIW)Regs:

(a) **Consignor** - the person who presents a consignment of controlled waste for transport. The consignor can be either the generator or the licensed collector. Transport approval shall be obtained from NEA to transport the waste.

(b) **Carrier -** the person who undertakes the transport of the controlled waste. He can either be the generator, the licensed

collector or the transport company engaged by either one of them.

(c) **Consignee** - the person who receives the controlled waste. He is usually the licensed collector.

(d) **Driver** - the driver of the vehicle transporting the toxic industrial waste.

3.6 To prevent illegal dumping and disposal of toxic industrial waste, the movement of every consignment of wastes from a generator through a carrier to a collector is tracked by means of an Internet based electronic submission of consignment note under the Waste and Resource Management System (WRMS).

4 Waste Minimisation

4.1 NEA formulates policies to promote and spearhead waste minimisation in Singapore. It works closely with the industries to promote waste minimization and some of the activities are as follows:

(a) **Waste Exchange**
NEA helps to link industries for exchange of wastes. Waste to one company may be a resource to another. For example, waste alkali generated by one company could be used by another company to neutralise the acidic wastes. This would minimise the ultimate quantity of wastes to be disposed of.

(b) **Use of Clean Technology**
At the planning consultation stage, NEA advises and encourages industries to use clean technologies which minimise waste generation.

(c) Reuse and Recycling
NEA encourages the recycling and reuse of wastes and assists in the setting up of waste recycling plants. Some of the wastes that are being recycled and reused in Singapore are discussed in Section 6.

(d) **Waste Audit**

NEA encourages those industries that generate large quantities of wastes to carry out waste audit. A waste audit is designed to achieve maximum resource optimisation and improved process performance. The audit enables one to take a comprehensive look at the process to understand the material flows and to focus on areas where waste reductions are possible. The waste audit can be carried out to cover a complete process or to concentrate on a selection of unit operations within a process. There are competent consultants in Singapore to carry out such waste audit for industries.

5 Some Practices Adopted for Recycling and Reuse of Wastes

5.1 A large amount of industrial waste generated and collected in Singapore by the licensed collectors are either recycled, reused or have valuable components extracted and recovered before disposal. Such wastes include spent solvents, spent etchants and photographic wastes.

5.2 Spent solvents are generated by a wide range of industries. Each year about 75,000 m^3 of spent solvents are collected by the licensed collectors. The spent solvents collected include acetone, chloroform, ethyl acetate, methylene chloride and toluene. About 35% of spent solvents are recovered by distillation. The practice adopted by these collectors is usually batch (differential) distillation. The equipment comprises a still to vapourise the solvents, a condenser to condense the vapours and collecting vessels to collect the condensate and the residues. The recovered solvents are sold for reuse by industries. The remaining spent solvents that could not be recovered are used as supplementary fuel for toxic waste incinerators.

5.3 Printing and film processing activities generate photographic wastes such as spent fixers and bleaches. These wastes contain silver in solution. An effective and commercially viable method, the electrolytic extraction process, is used to recover the silver. In this process, carbon is used as the anode and a stainless steel drum as the cathode. The silver is deposited on the stainless steel drum. The extracted silver has a purity of more than 90 %. The remaining liquid from the electrolysis process is treated and neutralised in a wastewater treatment plant before discharge into the sewers.

5.4 Etching is an important process used in the electronics industry especially in the manufacture of the printed circuit boards. The process generates spent etchants such as cupric chloride etchants, ferric chloride etchants and ammonia etchants. Each year about 10,000 m^3 of spent etchants are generated and treated in Singapore. Spent ferric chloride etchants are regenerated using scrap iron and chlorine. In this process, scrap iron is first added to the spent etchant and the copper sludge that precipitates out is collected and sold as a valuable by-product. The etchant is next regenerated by passing chlorine through it. The regenerated etchant is sold for reuse.

6 Monitoring and Enforcement

6.1 Any control system, no matter how well-crafted will not be effective without inspection and enforcement. Enforcement will ensure the minority of companies that violate the controls are penalised accordingly and would not gain unfairly from their violations. Without inspection and enforcement, companies that originally comply with the controls may become complacent and pay less attention and effort to ensure their operations continue to be safely managed.

6.2 Routine inspections are conducted on premises of toxic industrial waste collectors to ensure requirements on collection, storage, treatment, and disposal of toxic industrial waste are complied with.

7 Transboundary Movements of Hazardous Wastes

7.1 The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) was adopted in 1989 and came into force in 1992. The Convention aims to protect human health from the generation, transboundary movements and management of hazardous waste as defined under the Convention.

7.2 Singapore acceded to the Basel Convention on 2 Jan 1996 and on 16 Mar 1998 enacted The Hazardous Waste (Control of Export, Import and Transit) Act and its Regulations to strengthen the control on export, import and transit of hazardous waste in accordance with the principles and provisions of the Basel Convention.

7.3 Under the Hazardous Waste (Control of Export, Import and Transit) Act and its Regulations, any person who wishes to export, import or transit hazardous waste shall obtain a permit from NEA. The Prior Informed Consent (PIC) procedure of the Basel Convention is adopted in granting any permit for the export, import or transit of hazardous waste.

8 Conclusion

8.1 In addition to regulatory controls, the co-operation of industries in ensuring that toxic industrial waste are properly managed and disposed of in Singapore is essential. NEA will continue to work with industry and relevant stakeholders in promoting better management and disposal of toxic industrial waste through joint research and educational programmes.

8.2 NEA will continue to participate in international events on the Basel Convention and adopt the principles of Basel Convention in dealing with transboundary movements of hazardous wastes defined under the Convention.

ANNEX

LIST OF TOXIC INDUSTRIAL WASTE CONTROLLED UNDER THE ENVIRONMENTAL PUBLIC HEALTH (TOXIC INDUSTRIAL WASTE) REGULATIONS

List of Toxic Industrial Waste	
Acids 1 Spent inorganic acids E.g. hydrochloric acid, sulphuric acid, nitric acid, phosphoric acid, hydrofluoric acid, boric acid and pickling acid. 2 Spent organic acids E.g. acetic acid, formic acid, benzoic acid and sulphonic acid *Alkalis* 1 Spent alkaline solutions 2 Spent ammoniacal solutions 3 Metal hydroxide sludges and oxide sludges *Antimony and its Compounds* 1 Spent antimony potassium tartrate *Arsenic and its Compounds* 1 Timber preservative residues containing arsenic 2 Wastes containing gallium arsenide	*Copper Compounds* 1 Plating effluent and residues containing copper 2 Spent etching solutions containing copper from printed circuit board manufacturing 3 Timber preservative residues containing copper *Cyanides* 1 Plating effluent and residues containing cyanides 2 Heat treatment residues containing cyanides 3 Spent quenching oils containing cyanides 4 Spent processing solutions containing cyanides from photographic processing *Fluoride Compounds* 1 Timber preservatives residues containing fluoride 2 Spent ammonium bi-fluoride

Asbestos

1 Asbestos wastes from asbestos/cement manufacturing processes

2 Empty sacks/bags which have contained loose asbestos fibre

3 Asbestos waste generated from industrial activity, demolition, renovation and delagging works and ship repairing

Cadmium and its Compounds

1 Plating effluent and residues containing cadmium

2 Wastes containing cadmium from Ni/Cd battery manufacturing

Chromium Compounds

1 Plating effluent and residues containing chromium

2 Timber preservative residues containing chromium

3 Spent and aqueous solutions containing chromic compounds

4 Tannery effluent and residues containing chromium

Isocyanates

1 Spent di-isocyanates
E.g. toluene di-isocyanate (TDI) and methylene di-isocyanate (MDI) from polyurethane foam-making process

Laboratory Wastes

1 Obsolete laboratory chemicals

2 Toxic chemical wastes from chemical analysis

Lead Compounds

1 Sludges containing lead oxide/sulphate

2 Spent organo-lead compounds
E.g. tetraethyllead (TEL) and tetramethyllead (TML)

3 Waste lead-acid batteries, whole or crushed

Mercury and its Compounds

1 Effluent, residues or sludges containing mercury from chlor-alkali industry

2 Wastes containing mercury from equipment manufacturing involving the use of metal mercury

3 Spent catalysts from chemical processes containing mercury

4 Spent organo-mercury compounds

List of Toxic Industrial Waste	
Metal Catalysts 1 Spent metal catalysts from chemical processes and petroleum refining. E.g. catalysts containing chromium cobalt *Nickel Compounds* 1 Plating effluents and residues containing nickel *Organic Compounds containing Halogen* 1 Spent halogenated organic solvents E.g. trichloroethylene, 111-trichloroethane, perchloroethylene, methylene chloride, tetra-chloromethane and 112-trichloro-122-trifluoroethane 2 Residues from recovery of halogenated organic solvents 3 Packaging materials or residues containing chlorobenzenes and/or chlorophenals and their salts *Organic Compounds not containing Halogen* 1 Spent non-halogenated organic solvents E.g. benzene, toluene, xylene, turpentine, petroleum, thinner, kerosene, methanol, ethanol, isobutanol, isopropanol, methyl ethyl ketone, methyl isobutyl ketone, isopropyl ether, diethyl ether, hexane,	*Pathogenic Wastes* 1 Pathogenic wastes from hospitals 2 Pathogenic wastes from healthcare and research institutions, clinics and laboratories *Pharmaceutical Wastes* 3 Pharmaceutical wastes comprising antineoplastic agents, antibiotics, vaccines and other immunological products, controlled drugs under the Misuse of Drugs Act (Cap. 185) and pharmaceutical wastes containing arsenics, cyanides and heavy metals and their salts *Phenolic Compounds* 4 Sludges/residues from paint stripping using chemicals containing phenols 5 Residues containing unreacted phenol and formaldehyde from adhesive industry *Polychlorinated Bi-phenyl (PCB) Including Polychlorinated Ter-phenyl (PCT)* 1 Spent transformer oil containing PCB and/or PCT

dimethyl sulphide and dimethyl sulphoxide 2 Residue from recovery of non-halogenated organic solvents *Organotin Compounds* 1 Sludges, residues, effluents and spent blasting grit generated from removal of paints containing organotin compounds *Other Wastes* 1 Obsolete/abandoned chemicals and pesticides from storage, manufacturing and trading activities 2 Used containers, bags and process equipment contaminated by chemicals and pesticides from storage, manufacturing and trading activities 3 Waste/residues containing unreacted monomers E.g. vinyl chloride and styrene monomers, from polymer manufacturing processes 4 Tar residues from distilling and tarry materials from refining 5 Waste from toxic waste treatment processes E.g. wastes and residues from solidification, fixation and incineration processes 6 Wastes from toxic chemical drums and tank cleaning activities	2 Retrofilled transformer contaminated with PCB and/or PCT 3 Electrical equipment and parts containing or contaminated with PCB and/or PCT E.g. capacitors and transformers 4 Containers and all waste materials contaminated with PCB and/or PCT *Polyvinyl Chloride (PVC)* 1 All waste materials containing PVC E.g. PVC insulated wires, PVC pipes and trunking, PVC parts, PVC upholstery and PVC resins *Silver Compounds* 1 Spent processing solutions containing silver from photographic processing *Used, Contaminated Oil* 1 Used mineral, lubricating and hydraulic oil from machine cylinders, turbines, switch gears and transformers 2 Spent motor oils from petrol and diesel engines 3 Spent quenching oil from metal hardening

7 Chemical and oil slops from ship tankers 8 Waste from the production, formulation and use of resins, latex, plasticisers, glues/adhesives containing solvent and other contaminants 9 Waste from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish containing organic solvents, heavy metals or biocides 10 Solid wastes and sludges or obsolete/off specification materials not categorised elsewhere in the Schedule and failing the NEA's landfill disposal criteria	4 Oil recovered from solvent degreasers 5 Spent oil water emulsions E.g. spent coolants from metal working industries 6 Oil water mixtures (mainly oil) E.g. oily ballast water from ship tankers 7 Oil and sludge from oil interceptors 8 Tanker sludges and oil sludges/residues from storage tanks 9 Oil sludges containing acid from recovery and recycling of used oil *<u>Zinc Compounds</u>* 1 Plating effluents and residues containing zinc