

# **a guide for reduction and disposal of waste from oil refineries and marketing installations**

Prepared by:

D.A. Dando

D.E. Martin (Consultant)

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## ABSTRACT

This guide has been written primarily for those in the oil refining and marketing industry who have responsibility for the management of waste and its disposal. It should also provide useful information to the authorities who exercise legal control over these activities.

The guide lists the types of wastes commonly encountered in the industry and highlights techniques for minimising the quantities generated. Guidance is given on the methods of pre-treatment and disposal, together with information on how to select and monitor waste facilities and contractors, to ensure a high quality and safe disposal operation.

Information is also provided on documentation and labelling of waste cargoes and reference is made to legislation and sources of additional information.

While use of the guide cannot guarantee a problem-free operation, it will minimise the risks involved in disposal of waste materials from oil industry installations.

## KEYWORDS

Pollution, refinery, sludges, contaminated soil, legislation, minimisation, recycling, spent caustic, treatment, waste.

## INTERNET

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## SUMMARY

This guide (which is an update of the previous CONCAWE field guide 5/90) has been written primarily for those in the oil refining and marketing industry who have responsibility for the management of waste and its disposal. It should also provide useful information to the authorities who exercise legal control over these activities.

The guide is based upon the conventional Waste Management Hierarchy of prevention or avoidance first followed by re-use and only then consideration being given to disposal. The guide lists the types of wastes commonly encountered in the industry and highlights techniques for minimising the quantities generated. Guidance is given on the methods of pre-treatment and disposal. Generally the choice of treatment method is dictated by local circumstances and the guide indicates the factors which should be considered to make an effective technology choice. Information is also provided on how to select and monitor waste facilities and contractors, to ensure a high quality and safe disposal operation. This will help to facilitate a 'cradle to grave' monitoring approach.

Information is also provided on documentation and labelling of waste cargoes and reference is made to legislation and sources of additional information.

While use of the guide cannot guarantee a problem-free operation, it will minimise the risks involved in disposal of waste materials from oil industry installations. The two main pieces of EU legislation, the Waste Directive and the Hazardous Waste Directive, require local implementation. It should therefore be recognised that local regulations will differ from place to place and so the examples given and the methods proposed will require local interpretation.

## 1. INTRODUCTION

Current European Union Directives and national legislation, as well as the requirements of individual oil companies, demand that site operators maintain a strict control over the handling and disposal of their wastes.

CONCAWE has therefore produced this guide to pull together the experience of the European oil industry (refining and marketing), and to make it available to others, including waste site operators and control authorities. It is an update of CONCAWE field guide 5/90.

It is incumbent upon all waste holders to ensure that they take all reasonably practicable steps to dispose of their wastes in a manner that minimises risk to people and the environment. This has been the oil industry's practice for many years and is often referred to as the producer's "Duty of Care".

Experience has shown that what is considered, at a certain point in time, to be an acceptable disposal solution has the potential to become tomorrow's environmental problem. The choice of disposal routes and sites should make allowances for that possibility. Cost is invariably an important factor in the choice of a disposal route but it must be borne in mind that the future costs of dealing with inappropriately disposed of waste are likely to exceed those of the initial disposal by many orders of magnitude.

While use of this guide cannot guarantee a problem-free future, it should enable a waste holder to minimise the risk of incorrect disposal. Waste holders have an obligation to maintain "cradle to grave and beyond" knowledge and, as far as practicable, control, of their wastes, and the guide shows how that can be achieved in the oil industry.

## 2. LEGISLATIVE BACKGROUND

The operations of refineries are controlled by the IPPC Directive [3]. This covers all emissions of pollutants including wastes. There is a reference document on Best Available Technology for refineries [4] which has been produced by the European Institute for Pollution Prevention and Control (EIPPCB) at Sevilla. Although CONCAWE was involved in the production of this work, it felt that the document contained a number of shortcomings. These are described in a CONCAWE report [5]. There are also two BREFs in preparation covering Waste Incineration and Waste Treatments. Each of these will in due course be available on the EIPPCB website (<http://eippcb.jrc.es>).

There are, however, two main pieces of EU legislation specifically covering waste disposal i.e. the Waste Directive [1] and the Hazardous Waste Directive [2]. Both of these Directives have to be implemented into national legislation. Therefore, there are some differences in the ways that waste issues are handled in the various Member States. In particular, as allowable for environmental Directives, Member States are permitted to impose stricter restrictions than required by the Directives themselves. An analysis of such national differences is beyond the scope of this report. There are also a number of other Directives covering specific areas of waste disposal.

### 2.1. INTEGRATED POLLUTION PREVENTION AND CONTROL DIRECTIVE (IPPC)

### 2.2. WASTE DIRECTIVE

Waste is defined by the EU Waste Directive (as amended) [1] as:

“any substance or object in the categories set out in Annex I (*to the Directive*) which the holder discards or intends or is required to discard”.

This definition is very broad and there have been many court cases over what is and what is not waste. In most cases, it will be reasonably clear to site operators what the status of any particular material is. What is certain is that just because a material appears on a national or EU list of waste, does not necessarily imply that it should be treated as such in all circumstances. It is the **need to discard** something which is the deciding factor. This means that the same substance may be a waste in some circumstances but not in others.

The following are excluded from the scope of the Waste Directive:

- gaseous effluents emitted into the atmosphere; where they are already covered by other legislation;
- waste waters, with the exception of waste in liquid form;
- radioactive waste;
- waste resulting from prospecting, extraction, treatment and storage of mineral resources and the working of quarries;
- animal carcasses and the following agricultural waste: faecal matter and other natural, non-dangerous substances used in farming;
- decommissioned explosives.

The Directive also establishes a hierarchy of actions from waste reduction to reuse and only then disposal:

- (1) the prevention or reduction of waste production and its harmfulness, in particular by: - the development of clean technologies using less natural resources, - the technical development and marketing of products designed so as to make the smallest possible contribution, by the nature of their manufacture, use or final disposal, to increasing the amount or harmfulness of waste and pollution hazards, - the development of appropriate techniques for the final disposal of dangerous substances contained in waste destined for recovery;
- (2) the recovery of waste by means of recycling, re-use or reclamation or any other process with a view to extracting secondary raw materials, or the use of waste as a source of energy.

Member States have to designate the competent authority or authorities to be responsible for the implementation of this Directive. They have to take the necessary measures to ensure that any holder of waste:

- has the waste handled or transported by a private or public waste collector who holds the appropriate permit or;
- has the waste disposed of by a private or public waste handler who holds the appropriate permit or;
- recovers or disposes of it himself in accordance with the provisions of the Directive;
- maintains and keeps records of all waste movements.

### 2.3. HAZARDOUS WASTE DIRECTIVE

Certain wastes have been judged to be more dangerous than others and are defined as hazardous wastes. Such wastes are subject to stricter controls than non-hazardous waste. Hazardous waste is covered by Council Directive 91/689/EEC of 12 December 1991 (OJ L 377 31.12.1991 p.20) as amended [2] and is defined as:

“Wastes featuring on a list (**Section 2.4**) to be drawn up in accordance with Annexes I and II to Directive 75/442/EEC. These wastes must have one or more of the properties listed in Annex III (*of the Directive*). The list shall take into account the origin and composition of the waste and, where necessary, limit values of concentration.

Any other waste which is considered by a Member State to display any of the properties listed in Annex III.”

Note that again, the determining factor is not the appearance of a substance on the list of hazardous wastes but rather its properties and the concentrations of pollutants. However, the onus is on the holder of the waste to prove that any particular waste is not hazardous, and many regulatory authorities use the list of hazardous wastes as the determining factor.



The Directive further states that, on every site where tipping (discharge) of hazardous waste takes place, the waste is to be recorded and identified. Any establishment and undertaking which dispose of, recover, collect or transport hazardous waste must not mix different categories of hazardous waste or mix hazardous waste with non-hazardous waste. The derogation in Directive 75/442/EEC from the permit requirement for establishments or undertakings which carry out their own waste disposal shall not apply for hazardous waste. Hazardous waste must be properly packaged and labelled in accordance with the international and EU standards in force.

#### **2.4. WASTE CATALOGUE**

The EU Commission, has produced a list of wastes belonging to the categories listed in Annex I of the Waste Directive. This is the European Waste Catalogue. The list of hazardous wastes has now been amalgamated with this list [6] so that it includes all wastes, indicating those which may be hazardous with an asterisk. More recently, the Commission has produced a regulation requiring Member States to return statistics on wastes [7]. This also contains a list of waste categories which is different from the original list. It is not clear whether this is only to be used for statistical purposes.

#### **2.5. OTHER LEGISLATIVE INSTRUMENTS**

There are many other Directives and regulations covering waste disposal. The main ones cover landfill (**Section 7.2.1**) and incineration (**Section 7.2.3**). The Waste Oil Directive [8] and the regulations covering trans-border movements of waste are also of relevance. With regard to the latter the regulations are different depending whether the movement is to another EU country, to a developed nation, or to a less developed nation (normally not allowed) and whether the waste is for recovery or disposal. This subject is very complicated and frequently a source of cases in the European Court of Justice. At the time of publishing these regulations are under review.

A list of the main EU Directives and Regulations is given in **Appendix 1**. As mentioned earlier, there are local differences in waste legislation throughout Europe and it is the national legislation that site operators have to follow. This is beyond the scope of this report.

### 3. WASTE PRODUCTION

The generation of waste is an inevitable consequence of the operation of refineries and depots. Information on refinery wastes (although now rather old) can be found in CONCAWE report 1/95 [9]. Waste substances generated by oil company sites, fall into two categories:

- (a) Non-hazardous waste, e.g. scrap metal, spent catalytic cracking catalyst or "domestic" waste;
- (b) Hazardous waste, e.g. asbestos, acid tars, sludges with a high lead content or many oil contaminated materials.

Asbestos from any site should be considered hazardous. A definition of the term "hazardous" should be sought from national control authorities. Over-classification is definitely undesirable and use of appropriate lists and other tools as well as discussion with local waste disposal agencies used to ensure the correct classification. A list of typical oil industry wastes is given in **Appendix 2**.

The guidelines given in this report cover only wastes arising directly from industrial activities. Domestic type refuse, e.g. waste paper, is not included, being handled in the normal way by contract with local authorities.

Waste production in refineries and terminals represents a high operating cost and potential environmental risk, and as such its minimisation should be a priority.

## 4. WASTE MINIMISATION

For the purposes of this report, we have adopted the US EPA definition of waste minimisation [10] as “the reduction, to the extent economically feasible, of waste that is generated within a refinery or terminal and has subsequently to be disposed of”.

Waste minimisation includes the following key elements:

### 4.1. REDUCTION AT SOURCE

#### 4.1.1. Choice of process

At the project and design stage of equipment or process, attention should be paid to the waste generation aspect. Technologies that minimise or avoid waste should be preferred, e.g.:

- *Hydrogen Sulphide (H<sub>2</sub>S)/Mercaptan (RSH) removal from process streams:*  
Traditional caustic washing produces spent caustic. Selective removal of H<sub>2</sub>S with amines (regenerable process) and improved contactor design can minimise spent caustic production.
- *Cascading of Caustic Solutions: (Section 4.6).*

#### 4.1.2. Process / equipment modifications

In a number of cases, relatively minor changes can result in appreciable waste minimisation, e.g.:

- Mixers on crude oil storage tanks reduce sludge formation
- Closed loop sampling systems on product tanks reduce waste/slop oil production
- Re-sized/improved condensate knock out system on gas streams & on-site recycle
- Mechanical seals on pumps
- Use of antifoulants/corrosion inhibitors
- Dissolved air flotation (DAF) units: use of polyelectrolyte rather than inorganic flocculants to reduce the mass for final disposal.

#### 4.1.3. Alternative treatments

At times, the use of alternative treatments may result in either reduction or elimination of waste generation, or reduce the toxicity of the waste, e.g.:

- Hydrotreating instead of copper chloride sweetening
- Regenerative rather than once-through process (e.g. Merox process instead of caustic treatment)
- Hydrotreatment of lubricating oil products rather than acid treatment.

## 4.2. RECYCLING OF WASTES

### 4.2.1. Recycle / reuse within the company

Recycling and reuse of wastes minimises the quantity for disposal. This applies mainly to oily wastes although other materials are now being recycled. Strict segregation is required and correct choice of the addition point is important. The effect of contaminants e.g. lead on catalysts or halides (organic chlorides) in waste etc. must be considered.

Examples:

- Reprocessing off-specification products and recovered oil (e.g. oil from interceptor)
- Used refinery lubricating oils as fuel components (depending on local regulations)
- Oily emulsions processed by a distillation column (e.g. from DAF unit)
- Use of spent caustic instead of fresh caustic for corrosion control on distillation unit as part of an integrated caustic management system.

### 4.2.2. Recycle / reuse outside the company

Many types of refinery waste can be used in other industries, thereby minimising the quantities for disposal by the refinery. Care must be taken to ensure that the material is handled responsibly, in accordance with the law and in an environmentally acceptable manner.

Examples:

- Metal recovery from spent catalysts (desulphurisation, residue conversion)
- Use of vanadium containing catalysts in the steel industry
- Use of FCCU catalysts in road construction & cement works
- High severity re-refining of used lubricating oils:
- Reconditioning of drums/containers:
- Use of spent caustic:
  - in the pulp and paper industry
  - for production of  $\text{Na}_2\text{S}$  or  $\text{Na}_2\text{CO}_3$  and cresylic acids
- Use of calcium fluoride from the HF alkylation process
  - for HF production
  - as a fluxing agent (steel industry)
- Use of polymerisation catalyst as a fertiliser
- Sale of gypsum or sulphuric acid from flue gas desulphurisation units
- Paper, wood, glass, scrap metal for sorting and recycle
- Construction/demolition debris:
  - Use of crushed concrete in road building
  - Recycle of asphalt scrapings e.g. for road building.

#### 4.3. ECONOMY OF USE

Good plant operation and optimum use of chemicals etc. will result in minimisation of wastes for disposal, e.g.:

- Correct conditioning of a catalyst during a run extends catalytic life
- Control of sodium content in visbreaker feedstock reduces coke formation
- Process optimisation leads to less off-specification product and hence less recycle
- Recycling caustic sufficiently to ensure it is completely spent (**Section 4.6**).
- Water treatment chemicals added in a controlled manner to reduce excess sludge formation or scale build up.
- Use of polyelectrolyte chemicals rather than inorganic flocculants such as ferric chloride which generate excess sludge volumes.

#### 4.4. HOUSEKEEPING

Good housekeeping is essential to waste minimisation. Seemingly unimportant procedural aspects in operations and maintenance may have a large impact on waste operations. A closer analysis of how certain waste streams arise will, in some circumstances, allow complete elimination or at least a reduction of the waste stream in a relatively inexpensive way.

Proper material handling and storage minimises the possibility of spills, leaks and other losses which result in waste. Examples of proper storage and handling include:

- Storing drums off the floor to prevent corrosion through spills or concrete 'sweating'.
- Keeping containers closed except when removing material.
- Bunding of storage/process area to contain spills, with controlled drainage to a collection system e.g. interceptor.
- Using larger containers instead of drums. Larger containers are reusable when equipped for top and bottom discharge, whereas drums have to be recycled or disposed of as waste.

Elements of a spill and leak prevention programme could be:

- Equipping storage tanks with overflow alarms and automatic pump shut-offs.
- Installing double bottoms with integrated leak detection systems on tanks.
- Using (double) mechanical seals on pumps.
- Installing valves designed to minimise leakage.

When there is a risk of leaks or spills, the soil or floor should be rendered impermeable, and a collection system provided.

Cleaning, by its nature, generates waste. By choosing the right procedure and technique this waste may be minimised or its nature altered so as to make it more easily disposable. Some examples are:

- Using antifoulants in cleaning water to minimise the need for exchanger cleaning
- Draining equipment before cleaning to the maximum extent possible
- Recycling "spent" rinse water
- Using high pressure water or steam cleaning rather than detergents or chemicals
- Using on-site pre-treatment whenever possible, e.g.
  - Cleaning filter materials (e.g. filter clays) with water or steam prior to disposal to render them non-hazardous
  - Minimising tank sludge prior to cleaning (solvent, recirculation & mixers).

Solids entering the waste water sewer system can account for a large portion of the oily sludge. These can be reduced by:

- Using a road sweeper on paved areas
- Paving or planting ground cover on unpaved areas
- Cleaning solids from ditches and basins
- Segregating uncontaminated rain water from process effluent streams.

High pH materials (such as spent caustics), when discharged into a sewer system can precipitate insoluble materials adding to the sludge volume. Such high pH materials should instead be transferred directly to treatment or neutralised if they have to go to sewer first.

#### **4.5. WASTE HANDLING**

Waste handling, when correctly done, optimises the economics and decreases the ecological impact of the final disposal.

- Segregation of different wastes is a first priority. Addition of a small quantity of hazardous waste may change the classification of a large quantity of inert waste from non-hazardous to hazardous.
- Waste (pre)-treatment can often make the choice of final disposal easier or more economical. Treatment is preferably carried out on site, to reduce the risk of spills or accidents during transportation.

##### **4.5.1. Techniques**

###### **Sorting waste mixes e.g. concrete and scrap metal**

- Can be a cost-effective disposal route for some components
- Eliminates risk of unwanted components.

**Volume reduction**

- De-oiling/dewatering of sludge gives small volume of solid, low solvent waste, (e.g. centrifuge for oily sludges, belt press for biological sludges).
- Asbestos lagging: special equipment for compaction & packing.

Treatment to make waste environmentally more acceptable:

- TEL/TML scale & sludge: permanganate treatment eliminates toxic TEL/TML traces.
- Oiled solids (soil): de-oiling in an oil extractor.
- Neutralisation: mixing polymerisation catalyst ( $H_3PO_4$ ) with lime.
- Process treatment by steaming, flushing or regeneration prior to disposal: clay and sand filters; catalysts.

**4.6. HANDLING OF SPENT CAUSTIC SOLUTIONS**

Caustic is widely used in refineries and spent caustic presents special problems. An overall reduction in the caustic consumption of wet treating units can be obtained if semi-spent caustic from one treating unit can be re-used in another one. A typical example of this procedure is the use of the bleed of regenerated caustic (e.g. in sweeteners for FCC gasoline or for removal of  $H_2S$  or thiophenols) in a pre-wash step of non-catalysed cat cracked gasoline sweetening processes. An example of a caustic integration scheme is given in **Appendix III**.

Opportunities for minimisation of spent caustic use are as follows:

**Minimisation of spent caustic generation**

- Use of amines which are regenerable and also save energy,
- Use of high efficiency contacting systems rather than a simple washing, optimising usage and so reducing quantity.

**Reuse within refinery**

- Corrosion control on crude distillation units using spent caustic rather than fresh caustic.
- Addition to biotreaters for pH control.

**Reuse outside refinery**

- In paper mills (sulphidic caustic only)
- As raw material for  $Na_2SO_3$ , cresylics and  $Na_2CO_3$  (may require segregation of sulphidic, cresylic and naphthenic caustics).

**Disposal via the effluent system**

- pH adjustment and pre-treatment maybe required.
- This might entail:
  - oxidation to convert sulphides to thiosulphates,

- acidification/stripping/extraction to allow removal of H<sub>2</sub>S and organic acids,
- neutralisation.

Direct transfer to the effluent treatment system is preferred over disposal to sewer as this carries the risk of generating additional solids.



## 5. STORAGE

Wastes awaiting disposal must be stored in an environmentally acceptable manner, as approved by the local control authority. Storage must not give rise to secondary environmental problems such as odour or pollution of groundwater due to rainwater percolation through, or run-off from, the site. Storage should best be in closed vessels, containers or bags, on a site surrounded by a bund wall or toe wall, with drainage to a prepared system.

Pyrophoric materials must be kept either wet or sealed or blanketed with inert gas.

## **6. WASTE PRETREATMENT**

### **6.1. DEOILING/DEWATERING**

Dewatering/deoiling is used to decrease the quantity of waste for disposal and to recover oil mixed with the waste.

#### **6.1.1. Filtration**

Filtration is one means of dewatering sludge, but filters are generally more suitable for treating sludges with a low oil concentration because oil can blind/smear the filter cloth. Filtration usually yields a rather oily cake, and little oil in the liquid phase.

For dumping, filtration reduces the transport and disposal costs, because the sludge contains less water. If the final disposal route of the sludge is incineration, leaving more oil in the cake can reduce the fuel costs. If, however, the final disposal route is by dumping additional oil in the sludge can increase the disposal costs.

Filter aids may be required to reduce plugging tendencies.

##### **6.1.1.1. Filter press**

Filter presses (also called plate and frame presses) may be used to dewater many types of oily sludges. Sludge is applied to a cloth-covered filter plate at high pressure and water and oil are passed through the cloth media while solids are retained.

Parameters which are important are the feed temperature, the amount and nature of any additives such as lime/spent clay addition, cycle time, cake characteristics and filtrate characteristics. Heating the feed is advisable to obtain effective breaking of solids-stabilised emulsions. Pressure filters can handle feeds with concentrations up to 10% solids and having large proportions of difficult-to handle fines particles.

In the conventional Plate and Frame Press (PFP) a sequence of perforated square or rectangular plates alternating with hollow frames is mounted on suitable supports and pressed together with hydraulic or screw-drawn rams. The plates are covered with a filter cloth. The slurry is pumped into the frames and the filtrate is drained from the plates.

PFPs are most versatile since their effective area can be varied simply by blanking off some of the plates. Cake-holding capacity can be altered by changing frame thickness or by grouping several frames together. This is a batch process. Semi-continuous filters exist, but they are complicated and more expensive. Cake solids up to 50% can be obtained on pressure filtration with oil concentrations between 5 and 20%.

The filtrate is usually readily separable into oil and water phases once the stabilising solids have been removed. The water should be sent back to the waste water treatment plant.

For oily refinery sludge, filter presses have been used successfully. The cake contains 30-40% solids. Usually blinding of filter cloth by oil can be prevented by adding calcium carbonate sludge.

#### **6.1.1.2. Screen belt press**

The screen belt press is based on two transport belts, one above the other, with two countercurrent driving cylinders, which are adjustable for changing the pressure. The feed to the screen belt press is mixed thoroughly; usually flocculant is added. Such a press can achieve up to 20% solids in the sludge. The cake is scraped off at the end of the belt.

#### **6.1.1.3. Filter aids**

Filter aids include various grades of classified diatomaceous earth, calcined perlite and cellulose fibres. These are added to the system as a powder, which forms a cake of filter aid on the filter. When used to provide a pre-coat, they act as both surface and depth medium. When added to the filter feed as a body mix, they are deposited with the solids and form a porous structure that holds the solids but permits the liquid to flow through the cake. This increases the amount of solid material that can be collected from the sludge, in particular when it is slimy (e.g. biological sludge).

### **6.1.2. Centrifuging**

When considering dewatering by centrifuge, the first step is to analyse the solid, water and oil content of the sludge (mixture). If the oil content of the sludge is higher than 10%, then it is particularly worthwhile considering oil recovery.

The next step is to determine if the sludge supply is variable. For example, tank bottom sludges are not produced continuously. Loads should be accumulated and then mixed with other sludges. This can be done in the sludge-holding tank.

In the homogenisation tank the sludge should be mixed gently to prevent settling of the solids. This can be done by circulating pumps or by propeller mixers.

The feed to the centrifuge should pass through a simple strainer to take out coarse solids, and thus protect the centrifuge.

#### **6.1.2.1. Decanter centrifuge**

For dewatering refinery sludges by centrifuging, good experience is reported with horizontal scroll-type centrifuges (decanter). This method of dewatering results in a dry cake and a liquid consisting of oil and water and some solids.

The feed enters the machine and forms a concentric pool through which the solids settle to the outer wall. Solids are continuously removed by a scroll conveyor across a drying beach to discharge ports. The liquid flows counter-currently through a cylindrical section to an overflow weir of variable elevation, which affords pool-volume regulation.

The major process variables are the liquid and solids feed rates, and chemical conditioning of the sludges. If the feed rate is increased the retention time within the bowl decreases, reducing the clarification and dewatering capacity of the machine.

Polymers are normally added to the sludge feed to help capture fine solids, improve dewatering and optimise operation of the machine. The centrifuge has a certain solids handling capacity for specific machine parameters and for different sludges.

The two-phase scroll-type decanter centrifuge can handle a high content of solids in the feed (up to 25%). The decanter centrifuge is the most suitable centrifuge type for handling refinery sludges.

### **6.1.3. Drying of Sludges**

Drying of refinery sludges removes water and volatile organics by heating (e.g. using a steam coil). The vaporised materials are condensed and separated in a drum, into an oil phase and a water phase. The solid phase is discharged.

The feed to a thermal treatment unit (sludge-dryer) can be raw sludge or the solid phase from filter press or centrifuge. Thermal treatment has proved to be effective in processing biological effluent treatment sludge thereby converting the sludge into fertiliser/composting material. Alternatively, oil-containing sludges may be converted into (low grade) fuel pellets which can be used in other industries (e.g. cement industry).

## **6.2. SOLIDIFICATION, STABILIZATION AND ENCAPSULATION**

### **6.2.1. Process description**

Stabilisation and solidification are treatment processes designed to improve waste handling and physical characteristics, decrease surface area across which pollutants can leach, or limit the solubility of hazardous constituents. Suitable reagents include cement, lime or thermoplastic polymers. The following definitions are commonly used:

#### **6.2.1.1. Solidification**

A process in which materials are added to the waste to produce a solid. It may involve a solidifying agent that physically surrounds the contaminant (i.e. cement or lime), or it may utilise a chemical fixation process (i.e. sorbents). The resulting waste is usually an easily handled solid with low leachability.

#### **6.2.1.2. Stabilisation**

The conversion of a waste to a chemically stable form that resists leaching. This may be accomplished by a pH adjustment. Stabilisation also generally results in a solidification of some sort (monolith or dry granular solid).

#### **6.2.1.3. Encapsulation**

Complete coating or enclosure of a waste with a new, non-permeable substance.

### **6.2.2. Cement-based Processes**

#### **6.2.2.1. Mixing with cement**

In this process the slurried waste is mixed with cement and during the hardening process is incorporated in the rigid concrete matrices.

The process is especially effective when the waste contains metals because at the high pH of the cement mixture most metal compounds are converted into insoluble metal hydroxides. In the case of spent catalyst, most metal compounds are present as hydroxides which as such may also increase the strength and stability of the waste containing concrete. On the other hand, the presence of organic impurities may act as interfering agents to the curing of the concrete and this limits the application of this disposal route.

#### **6.2.2.2. Reuse of spent FCCU catalyst as feed to the cement industry**

Spent fluidised catalytic cracker unit (FCCU) catalyst may be used as an additive in cement manufacturing. When the cement is used, the catalyst component forms insoluble hydrates with the chalk present in the cement mixture, which also gives beneficial fixation of heavy metals.

#### **6.2.3. Chemical Stabilisation**

This process is based on the reaction of lime with waste materials and water to form a chemically stable product. The technique is suitable to immobilise watery sludges to yield a powdery hydrophobic product which can be compacted. The immobilised product is water-repellent and hardens with time and has very good properties for civil engineering applications such as foundations, tank bases, bund walls and road making.

When compacted, the porosity to water is very low. This reduces the risk of leaching.

#### **6.2.4. Micro-encapsulation and Macro-encapsulation**

Micro-encapsulation techniques are based on the reduction of surface-to-volume ratio of the waste by formation of a monolithic, hard mass with a very low permeability. Macro-encapsulation is the enclosing of a relatively large quantity of waste, such as an entire waste container. Wastes are macro-encapsulated by surrounding them with a stiff, weight-supporting matrix, and a seam-free jacket.

Encapsulation is suitable for the on-site treatment of disposal sites of accumulated spent acid tars and oily sludges which are difficult to transport and to dispose of by other means. A disadvantage is that the treated product occupies a larger volume than the original sludge.

Because it can be applied on-site, the encapsulation process may be considered for single applications like rehabilitating refinery sites after decommissioning or cleaning up an oil-polluted site after a spill. The decision to apply the process depends on the future use of the site and local legislation. The process is less attractive for the treatment of regularly produced sludges, because of the increased mass generated for disposal.

#### **6.2.5. Thermoplastic Techniques**

In general the use of thermoplastic solidification techniques is restricted to dry solid materials. This technique should not be used for wastes, containing:

- Organic chemicals (these may act as solvents).

- Oxidising salts (these can react with the organic material causing deterioration to the matrix material; at elevated temperatures these mixtures are extremely flammable).
- Dehydrated salts (e.g. sodium sulphate easily dehydrates at temperatures required to plasticise bitumen; when the bitumen matrix is soaked in water, rehydration of the sodium sulphate can occur, and this can cause the bitumen to swell and split apart).

The processing of waste with bitumen is applied in the oil manufacturing industry as a disposal method for spent FCCU catalyst and used for the production of a filler component in road asphalt where the catalyst is present as a minor component. The catalyst particles are completely encapsulated which makes aqueous extraction unlikely.

#### **6.2.6. Mixing With Asphalt**

This process allows treatment of soils with high levels (up to 10%) of high boiling range hydrocarbons. The soil is mixed with asphalt to produce a stable end product suitable for use in road construction.

## **7. WASTE DISPOSAL METHODS**

### **7.1. GENERAL**

All disposal must be carried out at suitability authorised and assessed facilities in accordance with the conditions laid down by the local control authority. In the event that incineration, recovery or reprocessing are involved, local company management should be satisfied that secondary waste generated by these processes is also disposed of at suitably authorised sites.

### **7.2. DISPOSAL ROUTES**

#### **7.2.1. Landfill**

The deposition of wastes on to land as a method of disposal will always be an activity which is controlled under legislation and there is a Landfill Directive [11] to control this in Europe. There is also an EU Decision [12] on the criteria for waste that can be accepted for landfill. In some countries it remains one of the cheaper methods of disposal although the shortage of satisfactory sites and the difficulties in obtaining consents from the regulatory authorities is driving prices higher.

The key consideration in the operation of a landfill site is the protection of groundwater from contamination by the materials contained in the landfill. It is therefore essential that:

- The lining of the containment is impermeable. Clay is the preferred material in many parts of Europe. In others, a lining of plastic sheeting is used. The integrity of synthetic liners is open to some doubt. In some countries it is required to have multi-layer linings with integrated drainage systems for new landfills.
- Monitoring boreholes are used in order to inspect the effectiveness of the containment.
- The deposition of liquid wastes is not permitted except under rigorously controlled conditions. Whether or not liquid deposition is allowed, arrangements should be made for the collection and treatment of leachate.

The second consideration for the disposer is that wastes deposited in landfill are not immediately destroyed but only stored. They must not be capable of reacting in a harmful way to generate heat or noxious gases. If flammable gases e.g. methane are generated, they should be collected. Because it is likely that an open-ended civil liability will exist, it is important that the disposal site be run either by the holder of the waste who will then retain responsibility for his own waste, or by a disposal site operator of impeccable repute.

#### **7.2.2. Underground Storage**

One of the disposal routes which is used for hazardous materials is the underground storage in worked-out salt mines and caverns. However, there are no reports available which confirm that this type of underground storage is being used for refinery waste in Western Europe.

The materials being disposed in this way are reportedly:

- Persistent chemical waste
- Dioxin containing sludges (from dump site leachate treatment)
- Nuclear waste
- Other hazardous materials.

Various types of underground storage have been used or proposed in different parts of the world. These are:

- Deposition in old excavated salt mines
- Deposition in used brine wells
- Injection into deep rock strata.

As with landfill deposition, the key factor is the risk of groundwater contamination. The principal considerations associated with this are:

- The mechanisms by which contaminant migration can be prevented
- The methods available to detect contaminant migration if it should occur
- Possible remedial actions.

Deep deposition precludes any real possibility of effective monitoring or remedial action. The integrity of the system depends therefore on the certainty that contaminant migration will not occur. Such certainty, in turn, depends on a comprehensive knowledge of the surrounding geology and on the assurance that no faults or fissures are present.

The choice of disposal route obviously depends on local records and on the nature of the waste to be disposed of.

Sedimentary deposits of salt will not usually present an irregular geological structure, but the use of disused salt mines or brine wells is limited to dry wastes or water insoluble wastes for obvious reasons.

Injection into deep rock and clay strata has been considered for wastes from the nuclear industry, and is used for some oil industry wastes.

### **7.2.3. Incineration**

Any process that uses combustion to convert a waste to a less bulky, less toxic or less noxious material is called incineration. Incineration is controlled in the EU by the Waste Incineration Directive [13]. This covers the incineration of both hazardous and non-hazardous waste and sets emission limits for incinerators.

An incineration system must produce as complete a combustion as practical using an optimum selection of process parameters (time, temperature and turbulence) and provide air pollution control devices to minimise the emission of air pollutants. Many waste materials are readily combustible and the products of their combustion are harmless gases which are easily disposed of through vents or stacks to the



atmosphere. In such cases, incineration is often the soundest method of waste disposal.

#### **7.2.4. Types of Incinerators**

##### **7.2.4.1. Fixed hearth incinerators**

In its simplest form, a fixed hearth incinerator is a refractory lined chamber into which solid or sludge waste is introduced through a side port. Waste accumulates on the hearth where it is ignited and burned to ash.

Because the solids, sludges and high viscosity liquids will not be mixed thoroughly with combustion air in a fixed hearth, a provision must be made to enhance destruction of all organics by adjusting the rates of waste introduction and ash removal.

Experience has shown that maintenance costs are low because there are few internal moving parts. Because this type of incinerator can be constructed in small sizes, it is frequently employed for batchwise destruction of small quantities of waste at the site of generation. It is not usually applied to destroying large volumes of wastes and it is not often used in refineries. These incinerators can handle wastes such as oil spill debris or contaminated soils, activated carbon, plastic, resins, desiccants, sorbents, asphalt, wood and paper.

##### **7.2.4.2. Multiple hearth incinerators**

The multiple hearth incinerators are capable of handling high volume of waste and may use supplementary fuel. The incineration chamber is almost always a vertical steel cylinder, lined with refractory. A number of horizontal platforms are located at various levels in the chamber and the top platform usually receives a continuous charge of waste material.

Multiple hearth incinerators are best suited to wastes with a high water content and of a uniform particle size (sludge).

Maintenance is high because of internal moving parts. Capital costs are high and multiple hearth technology has very limited applications in refineries.

##### **7.2.4.3. Fluidised bed incinerators**

In a fluidised bed incinerator, the sludge is pumped into a hot fluidised bed of special sand about 1-3 mm mean diameter. This ensures that any volatilised material is combusted.

The fluidised bed incinerator is used to burn sludges partially dewatered and pumped to the unit with a solids content of up to 5-6% mass. If support fuel is required refinery gas can be used.

Air for combustion and fluidisation is provided by a compressor and is pre-heated before passing into the incinerator bed.

The main advantage of this type of incinerator is its flexibility to accommodate large variations in sludge composition.

#### **7.2.4.4. Rotary kiln incinerators**

The rotary kiln incinerators are considered the most versatile and most durable of the common incinerator types. They can incinerate almost any waste, regardless of sizes and composition. A rotary kiln incinerator is a refractory lined cylindrical steel shell slightly tilted on its horizontal axis. The shell is usually supported on two or more heavy steel tracks which surround the shell. These ride on rollers allowing the kiln to rotate around its longitudinal axis. Waste material is "tumbled" through the kiln by gravity as it rotates. The rate of rotation and angle to tilt determines the amount of time the waste is held in the kiln (solids residence time). Rotary kilns can receive solid waste through one end which is non-rotating by means of an auger screw or ram feeder. Pumpable, non-dispersible waste and sludges may be introduced through a water cooler tube and liquid waste may be injected into the kiln through a burner nozzle. As with a liquid injection incinerator, auxiliary fuel can be fired into the kiln chamber. Combustion air can be introduced in a variety of ways to enhance turbulence in the kiln chamber.

Kilns often have secondary combustion chambers and usually are equipped with air pollution control. Because of its versatility and durability, a rotary kiln can treat virtually any hazardous waste, including drums and packaged wastes.

#### **7.2.4.5. Liquid fuel incinerators**

A liquid waste fuel must be changed to gas to burn and this requires that waste must be pumpable and atomisable (dispersible into very small droplets). The waste is delivered to the incinerator by a conventional pumping system and passes through a burner into the incinerator chamber.

#### **7.2.4.6. Gas or fume incinerator**

These are incinerators which burn only gas or volatilised material (fumes). They are very similar to liquid injection types except that the fluid is a gas instead of a liquid.

**Appendix IV** provides some general guidance on the types of incinerators for combusting industrial wastes.

#### **7.2.5. Pyrolysis**

Pyrolysis is a thermal conversion of solid wastes, biomass etc. generating quantities of a high calorific value gas which can be burned further in a furnace or in an incinerator. This process has not been applied in refineries for waste and sludge treatment because incineration is simpler and therefore is preferred.

#### **7.2.6. Biodegradation Methods**

Many hazardous chemicals present in refinery waste can be converted by microbiological methods to harmless compounds such as water and carbon dioxide.

In general, the microbiological degradation of contaminants in soil is very slow in nature, because process conditions for such degradation are seldom favourable. To accelerate degradation a number of conditions have to be fulfilled. The most important factors are the availability of sufficient oxygen, nutrients, and the appropriate micro-organisms. Also important are the concentration level of the contaminants and the variation in concentration. The presence of toxic compounds

can disturb the degradation process. Sometimes the presence of natural organic compounds has a positive influence on the biodegradation process.

Current techniques for biological decontamination are based on optimisation of the process conditions for microbiological degradation. The appropriate micro-organisms may already be present in the soil to be treated or may have to be added. The latter is necessary if special micro-organisms are required. These special micro-organisms can be developed by selection and adaptation.

In summary the following conditions have to be met in order to optimise the degradation rate:

- Sufficient number of micro-organisms of the right strains,
- Non-toxic concentrations of contaminants or other compounds,
- Presence of sufficient water (10-15% mass in soil),
- Presence of sufficient nutrients (mainly P and N in ratio 1:10),
- Presence of sufficient oxygen for aerobic processes and a full depletion of oxygen for anaerobic processes,
- Favourable temperature (10-30°C),
- Sufficient availability of contaminants (preferably without high peak concentrations) to the micro-organisms,
- Soil of pH 6-8,
- Temperature control.

Several types of techniques are available for the micro-biological treatment of contaminated soil.

#### **7.2.6.1. Landfarming**

Landfarming systems have been used for the treatment of petroleum industry wastes for many years. The process involves the controlled application of waste on a soil surface in order to biodegrade the carbonaceous constituents by utilising the micro-organisms that are naturally present in the soil. The conditions under which the degradation takes place are typically aerobic.

Landfarming should not be confused with land filling, in which the waste is deposited in man-made or natural excavations for an indefinite period of time. The conditions under which land-filled wastes are stored are typically anaerobic.

In most locations permission from the authorities is required before a landfarming facility can be started. In a number of countries the technique is not permitted at all.

Landfarming is a relatively cost-effective and simple technique, which is environmentally acceptable provided that it is properly designed, operated and monitored (also with respect to leachate and run-off). However, uncontrolled landfarming is unlikely to be acceptable today and has largely been replaced by more controlled operations such as those listed below.

#### **7.2.6.2. Composting**

In composting techniques, enforced aeration of the soil takes place. These techniques are, to a very large extent, similar to the open and closed composting systems, already used in practice for treating organic wastes. Some adaptation is necessary, due to the fact that the mechanical/physical behaviour of soil is different from that of organic wastes. Also for these techniques treatment periods of one to two years may be necessary.

However, experience with commercially available bio-treatment processes with oil contaminated soil in contained areas with controlled climate (in housings) shows that the degradation process can be accelerated to a few months or even few weeks.

#### **7.2.6.3. Biopiling**

Biopiling is an adaptation of the landfarming and composting techniques. Oily sludge is mixed with soil (as a source of bacteria), treated with a pre-determined amount of nutrients, and maintained in a controlled climatic environment under optimum conditions of temperature, air and moisture levels. Biodegradation proceeds rapidly, and (with control authority agreement) the end product is suitable for use as cover material on completed waste tips or in landscaping areas.

Biopiles may vary from highly engineered commercial facilities to minimally engineered temporary ones such as tarpaulin covered soil/sludge piles.

#### **7.2.6.4. Mechanised Processes**

The third category consists of the wet and dry bioreactors and/or fermenters in which the soil is continuously mixed intensively.

The biological composting/decontamination process can be accelerated if the necessary process conditions are closely controlled and monitored. This is not possible in housings but can be achieved in vessels, which are vacuum and pressure tight.

There are bioreactors and fermenters designed, manufactured and already in commercial operation which meet the following conditions:

- Capacity: up to 200 tons for a single charge
- Vacuum or pressure operation
- Humidity control
- Operation under aerobic or anaerobic conditions
- Mechanical stirring of the entire charge
- Residence time between few hours and few days depending on type and grade of contamination. Typical hydrocarbons need a few hours to degrade (whereas PCBs require several days).

### **7.2.7. Disposal of Spent Catalysts**

Refinery catalysts typically consist of metals supported on an inert carrier such as alumina, silica or activated charcoal. The metals may be precious, such as platinum or rhenium in a reformer catalyst, or heavy base metal elements such as nickel, molybdenum, cobalt, tungsten, and vanadium e.g. nickel-molybdenum for a hydrotreater catalyst. Sometimes non-metal catalysts are used such as phosphoric acid in the catalytic polymerisation process. In use, the catalysts become contaminated with metals such as lead, arsenic, nickel and vanadium, non metals like sulphur and carbon, and significant quantities of hydrocarbon products and residues.

In view of the metals value, spent catalysts containing precious metals are returned to the manufacturers for regeneration, whilst others are sent for metals reclamation and recycling. Other industries can also use spent catalysts in the manufacture of other products: e.g. those containing nickel, cobalt and molybdenum can be used in the production of ceramic tiles. Waste catalyst can also be combined with waste products from other industries to make useful products: e.g. catalysts containing phosphoric acid can be mixed with aluminium industry waste alkali mud to make a soil amendment product. Spent catalysts containing metals can also be used as a component in cement manufacture or be combined with asphalt as a road base.

Those catalysts which contain activated charcoal, or are highly contaminated with hydrocarbon residues, have a calorific value which can be used as fuel in e.g. cement manufacture. Those catalysts which cannot be recycled/reclaimed have to be disposed of by other approved routes such as e.g. landfill.

### **7.3. CO-MINGLING OF WASTE**

In some countries the co-mingling of non-hazardous wastes with hazardous materials from elsewhere (and vice versa) is not permitted, while in others, this is a recognised and accepted means of disposal. The microbial organisms generated in the non hazardous wastes can destroy the toxic elements in the hazardous waste.

Whatever the legal situation, this practice is not normally recommended as the inclusion of even a small quantity of hazardous waste in a consignment of non-hazardous waste will render the whole consignment hazardous. In any event, the location of a company's wastes within a disposal site should be ascertained. In addition, the number of disposal sites utilised should be minimised. It is not good practice to "spread the waste around".

### **7.4. SELECTION OF WASTE DISPOSAL ROUTE, SITE AND CARRIER**

The aim of this Section is to recommend, in simple practical terms, the way in which the above should be selected. It starts from the point at which a company has considered how to minimise the environmental impact of a particular industrial activity and has concluded that the best practicable environmental option entails the consignment of a particular solid or liquid waste to landfill, biodegradation or incineration.

It is recommended that the following steps are taken to ensure that "Duty of Care" is adequately fulfilled.

**STEP 1 - Identification of Suitable Waste Disposal Sites**

Determine the hazard characteristics of the waste and whether or not it requires special treatment. Determine the optimum batch size for disposal and the frequency of arising of the waste. In conjunction with the local waste disposal authority, identify the disposal methods likely to be acceptable and the sites appropriately authorised to receive such waste.

For each waste disposal site to be considered:

- Obtain a copy of the relevant waste disposal licence (or authorisation),
- Check the technical and financial standing of the operating company and its insurance cover.

**STEP 2 - Assessment of Disposal Site Management and Operation**

Before selection, the proposed disposal site should be visited by an assessment team, normally consisting of at least two persons who have between them, intimate knowledge of the variability of the waste in question and general experience of the method of waste disposal proposed.

Consider the following questions:

**All Disposal Sites**

- (1) Are operatives aware of the disposal principles applying?
- (2) Is there a responsible attitude to acceptance and treatment of wastes?
- (3) Are all loads weighed into the site?
- (4) Are full records kept of all loads received?
- (5) Is there adequate segregation of waste types?
- (6) Is the site secure against intruders?
- (7) Does the site have a good safety record?
- (8) Is the housekeeping good?
- (9) Is the site a source of neighbourhood nuisance?
- (10) Do vehicles leave with dirty tyres?
- (11) Have there been any convictions for waste disposal offences?
- (12) Are there written operating procedures?
- (13) Are there written emergency procedures?
- (14) Are there adequate fire fighting facilities?
- (15) Are safety and environment protection facilities adequate?

- (16) Are operatives provided with appropriate protective equipment?
- (17) Is any special insurance carried for risks associated with waste handling?

#### **Landfill and Biodegradation Sites**

- (18) Is there a rational plan for site utilisation?
- (19) Are there records of placings of all hazardous loads?
- (20) Is all water run-off controlled and adequately treated?
- (21) Is there adequate protection against groundwater contamination?
- (22) Is there any provision for laboratory testing of wastes, groundwater and leachates?

#### **Incineration Sites Only**

- (23) Is there a smoke or other fume problem?
- (24) Is the stack particulates removal adequate?
- (25) Are records of incinerator temperature available?
- (26) Is the process temperature control reliable?
- (27) Is site drainage disposed of correctly?
- (28) Are incinerator ash and other site wastes disposed of correctly by an acceptable route?
- (29) What assurance is there that wastes for incineration are properly incinerated?
- (30) Is any waste pre-treatment performed in an acceptable manner?

In addition to these checks, the suitability of the site for the waste in question should be discussed with the waste disposal authority responsible for the site.

If any doubt remains over the adequacy of the site for collection and disposal of leachate waters from the wastes, discuss this matter with the water control authority responsible for the area.

If any doubt remains over possible neighbourhood nuisance from an incinerator used to burn waste, discuss this matter with the air pollution control authority.

#### **STEP 3 - Selection and Assessment of a Waste Carrier**

Having selected a waste disposal site and determined the waste production rate, a waste carrier must be selected who can be relied upon to transport the waste safely, cleanly and efficiently from the company's site to the waste disposal site. Waste carriers not used previously should be assessed by company representatives experienced in the employment of waste contractors.

Consider the following questions:

- (1) Do the proposed carriers have experience of carrying the types of waste in question and of waste disposal site operations?
- (2) Do they keep good records of waste loads carried?
- (3) Do they have equipment suitable for handling the waste in question?
- (4) Do they have equipment suitable for operation within petroleum sites?
- (5) Are operatives provided with appropriate protective equipment?
- (6) Have there been any convictions for waste disposal offences?
- (7) Is any special insurance carried for risks associated with waste handling?
- (8) Do they know how to react to spillages and do they carry equipment/ protection to deal with spillages?

Contact for "references", the waste disposal authority within whose area the carrier's business is registered.

#### **STEP 4 - Follow-up**

Keep good records of the quantities and compositions of all waste consignments dispatched to disposal sites.

Make periodic audit visits to the waste disposal site to assess ongoing acceptability of the disposal methods employed. Record observations made during these visits.

In the case of hazardous wastes, keep and update a plan of the waste disposal site marked up to show the area in which waste has been placed in case of future liability.

### **7.5. DISPOSAL COSTS**

There is significant variation in disposal costs among countries and in general there is an upward trend. Thus, economically favourable processes in one country may be prohibitively expensive in another country. For these reasons, no effort has been made to specify costs in this guide.



## 8. DOCUMENTATION AND LABELLING OF WASTES

### 8.1. DOCUMENTATION

All waste moved from oil company sites to disposal sites must be accompanied by some type of waste transfer advice form, as agreed between the company site management and the local control authority. This is to ensure that:

- Control authority requirements are met; and
- Records are maintained of all waste movements from company sites.

Contact should be made with local authorities to ascertain their requirements. In the event that there are none, an "in-house" system should be established.

### 8.2. LABELLING OF CARGOES

Wastes for disposal may be transported by road, rail, sea or even air, and in each case it is necessary to ensure that the consignment is labelled in accordance with national and international regulations. Since these will vary between countries and across national boundaries, requirements should be checked with local and national control authorities.

In any event, the minimum labelling that is required to fulfil a "duty of care" commitment is:

- The name of the waste,
- The name, address and telephone number of the holder,
- Any potential safety or environmental hazards (e.g. release of H<sub>2</sub>S),
- Precautions and action required in the event of a spillage,
- Flash point (if appropriate),
- Address and telephone/fax number for specialist advice.

In some countries considerably more detail than this is required, and so it is most important that local regulations be consulted. Since these can change quite quickly, no attempt has been made to list them in this guide. However, attention is drawn to the EU legislation listed in **Appendix I**.

## 9. REFERENCES

1. EU (1975) Council Directive 75/442/EEC of 15 July 1975 on waste. Official Journal of the European Communities No. L194, 25.07.1975
2. EU (1991) Council Directive 91/689/EEC of 12 December 1991 on hazardous waste. Official Journal of the European Communities No L377, 31.12.1991
3. EU (1996) Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control. Official Journal of the European Communities No. L257, 10.10.1996
4. EIPPCB (2003) Integrated Pollution Prevention and Control (IPPC) – Reference document on best available techniques for mineral oil and gas refineries. Seville: European IPPC Bureau
5. CONCAWE (2003) The IPPC directive, refinery BREF, and european refineries – a guidance manual. Report No. 4/03. Brussels: CONCAWE
6. EU (2000) Commission Decision 2000/532/EC of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste. Official Journal of the European Communities No. L226, 06.09.2000
7. EU (2002) Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics. Official Journal of the European Communities No. L332, 09.12.2002
8. EU (1975) Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils. Official Journal of the European Communities No. L194, 25.07.1975
9. CONCAWE (1995) Oil refinery waste disposal methods, quantities and costs - 1993 survey. Report No. 1/95. Brussels: CONCAWE
10. US EPA (1988) Waste minimization opportunity assessment manual. EPA/625/7-88/003. Washington DC: US Environmental Protection Agency
11. EU (1999) Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste. Official Journal of the European Communities No. L182, 16.07.1999
12. EU (2003) Council Decision 2003/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC. Official Journal of the European Communities No. L11, 16.01.2003
13. EU (2000) Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste. Official Journal of the European Communities No. L332, 28.12.2000

## APPENDIX I EU WASTE LEGISLATION

Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils (OJ L 194 25.07.1975 p.23). As amended by Directives 2000/76 (OJ L 332 28.12.2000 p.91), 1987/101 (OJ L 042 12.02.1987 p.43) and 1991/692 (OJ L 377 31.12.1991 p.48)

Council Directive 75/442/EEC of 15 July 1975 on waste (OJ L 194 25.07.1975 p.39) as amended by Directives 91/156 (OJ L 078 26.03.1991 p.32), 91/692 (OJ L 377 31.12.1991 p.48) and 96/350 (OJ L 135 06.06.1996 p.32)

Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (OJ L 181 04.07.1986 p.6). As amended by 3 Directive 1991/692 (OJ L 377 31.12.1991 p.48) and Directive 2003/807 (OJ L 122 16.05.2003 p.36)

Council Resolution of 21 December 1988 concerning transfrontier movements of hazardous waste to third countries (OJ C 009 12.01.1989 p.1)

Council Resolution of 7 May 1990 on waste policy (OJ C 122 18.05.1990 p.2)

Council Directive 91/689/EEC of 12 December 1991 on hazardous waste (OJ L 377 31.12.1991 p.20). As amended by Directive 1994/031 (OJ L 168 02.07.1994 p.28)

Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community (OJ L 030 06.02.1993 p.1). As amended by Regulations 1997/120 (OJ L 022 24.01.1997 p.14), 1999/816 (OJ L 316 10.12.1999 p.45) and 2001/557 (OJ L 349 31.12.2001 p.1)

Commission Decision 94/774/EC of 24 November 1994 concerning the standard consignment note referred to in Council Regulation (EEC) No 259/93 on the supervision and control of shipments of waste within, into and out of the European Community (OJ L 310 03.12.1994 p.70)

Council Directive 94/67/EC of 16 December 1994 on the incineration of hazardous waste (OJ L 365 31.12.1994 p.34). Also see 32000L0076 (OJ L 332 28.12.2000 p.91)

Council Directive 96/59/EC of 16 September 1996 on the disposal of polychlorinated biphenyls and polychlorinated terphenyls (PCB/PCT) (OJ L 243 24.09.1996 p.31)

Council Resolution of 24 February 1997 on a Community strategy for waste management (OJ C 076 11.03.1997 p.1)

Council Decision 97/640/EC of 22 September 1997 on the approval, on behalf of the Community, of the amendment to the Convention on the control of transboundary movements of hazardous wastes and their disposal (Basle Convention), as laid down in Decision III/1 of the Conference of the Parties (OJ L 272 04.10.1997 p.45)

Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182 16.07.1999 p.1)

Council Regulation (EC) No 1420/1999 of 29 April 1999 establishing common rules and procedures to apply to shipments to certain non-OECD countries of certain types of waste (OJ L 166 01.07.1999 p.6). As amended by 2000/1208 (OJ L 138 09.06.2000 p.7), 2000/2630 (OJ L 302 01.12.2000 p.35), 2001/1800 (OJ L 244 14.09.2001 p.19), 2001/2243 (OJ L 303 20.11.2001 p.11), 2001/77 (OJ L 011 16.01.2001 p.14) and OJ L 014 19.01.1999 p.24

Commission Regulation (EC) No 1547/1999 of 12 July 1999 determining the control procedures under Council Regulation (EEC) No 259/93 to apply to shipments of certain types of waste to certain countries to which OECD Decision C(92)39 final does not apply (OJ L 185 17.07.1999 p.1). Amended by 2000/334 (OJ L 041 15.02.2000 p.8), 2000/R354 (OJ L 045 17.02.2000 p.21) 2000/1208 (OJ L 138 09.06.2000 p.7), 2000/1552 (OJ L 176 15.07.2000 p.27) 2001/1800 (OJ L 244 14.09.2001 p.19), 32001/2243 (OJ L 303 20.11.2001 p.11) and 2001/77 (OJ L 011 16.01.2001 p.14)

Council Decision 2000/33/EC of 19 December 2002 establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 of and Annex II to Directive 1999/31/EC (OJ L 011 16.01.2003 p.27)

Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues - Commission declaration (OJ L 332 28.12.2000 p.81). Amended by 2002/84 (OJ L 324 29.11.2002 p.53)

Commission Decision 2000/532/EC of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (notified under document number C(2000) 1147) (OJ L 226 06.09.2000 p.3). Amended by Decisions 2001/118 (OJ L 047 16.02.2001 p.1) and 2001/119 (OJ L 047 16.02.2001 p.32) and 2001/573 (OJ L 203 28.07.2001 p.18) Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (OJ L 332 28.12.2000 p.91)

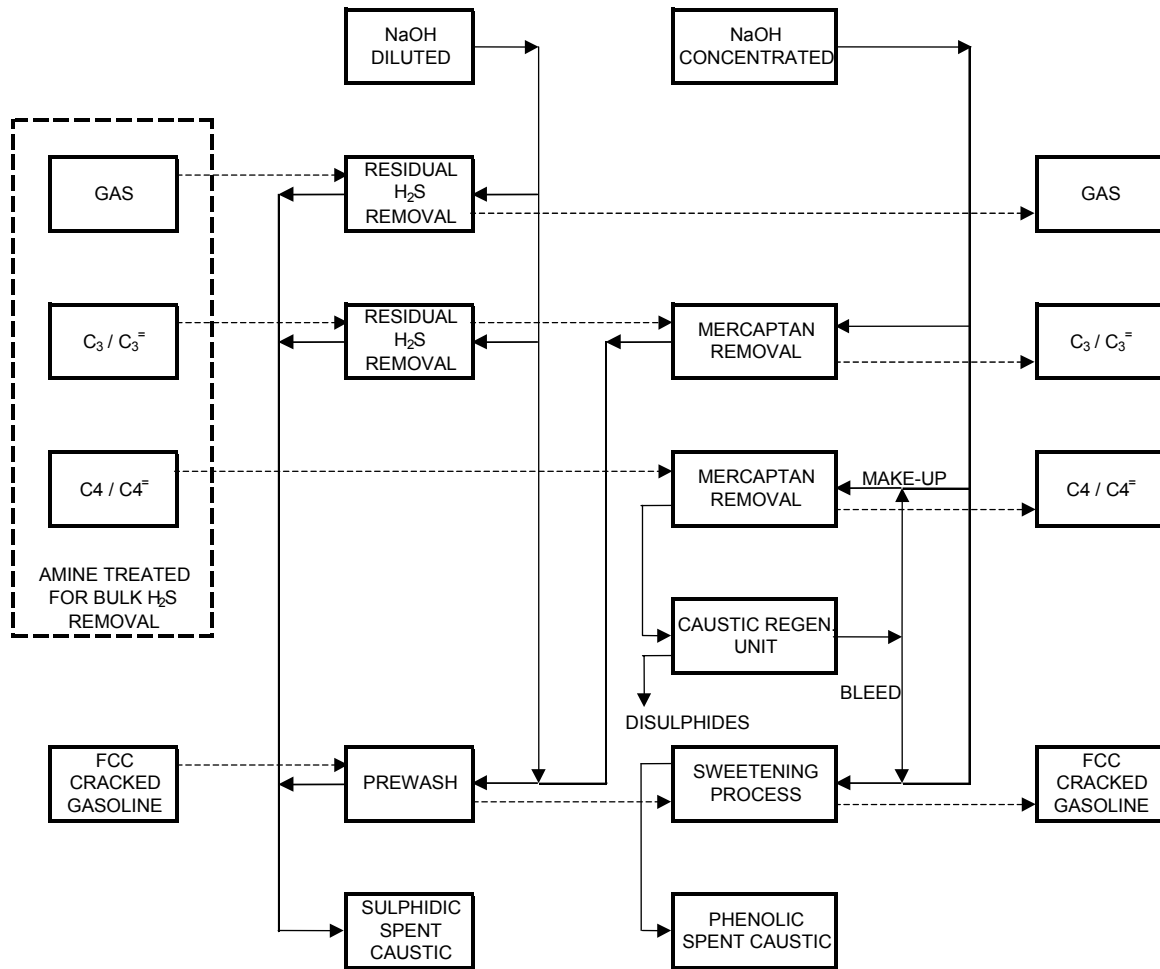
Regulation (EC) No 2150/2002 of the European Parliament and of the Council of 25 November 2002 on waste statistics (OJ L 332 09.12.2002 p.1)

## APPENDIX II TYPICAL WASTE TYPES

<b>Oiled materials</b>	<ul style="list-style-type: none"> <li>• <i>oily sludges</i> <ul style="list-style-type: none"> <li>tank bottoms</li> <li>biotreatment sludges</li> <li>interceptor sludges</li> <li>waste water treatment sludges</li> <li>contaminated soils</li> <li>desalter sludges</li> </ul> </li> <li>• <i>solid materials</i> <ul style="list-style-type: none"> <li>contaminated soils</li> <li>oil spill debris</li> <li>filter clay acid</li> <li>tar rags, filter materials, packing, lagging activated carbon</li> </ul> </li> </ul>
<b>Drums and containers</b>	<ul style="list-style-type: none"> <li>metal</li> <li>glass</li> <li>plastic</li> <li>paint</li> </ul>
<b>Spent Catalysts</b> (excluding precious metals)	<ul style="list-style-type: none"> <li>FCCU (fluid bed catalytic cracking unit)</li> <li>HDS/HT (hydrodesulphurisation/hydrotreatment)</li> <li>polymerisation unit</li> <li>residue conversion</li> </ul>
<b>Non-oiled materials</b>	<ul style="list-style-type: none"> <li>resins</li> <li>boiler feed water sludges</li> <li>desiccants and absorbents</li> <li>neutral sludges from alkylation plants</li> <li>FGD wastes (flue gas desulphurisation)</li> </ul>
<b>Radioactive wastes</b>	<ul style="list-style-type: none"> <li>catalysts</li> <li>laboratory waste</li> </ul>
<b>Scales</b>	<ul style="list-style-type: none"> <li>leaded/unleaded scales</li> <li>rust</li> </ul>
<b>Construction/ demolition debris</b>	<ul style="list-style-type: none"> <li>scrap metal</li> <li>concrete</li> <li>asphalt</li> <li>soil</li> <li>asbestos</li> <li>mineral fibres</li> <li>plastic/wood</li> </ul>
<b>Spent chemicals</b>	<ul style="list-style-type: none"> <li>laboratory</li> <li>caustic</li> <li>acid</li> <li>additives</li> <li>sodium carbonate</li> </ul>

	solvents MEA/DEA (mono/di-ethanol amine) TML/TEL (tetra methyl/ethyl lead) unknown (product x)
<b>Pyrophoric wastes</b>	scale from tanks/process units
<b>Mixed wastes</b>	domestic refuse vegetation
<b>Waste oils</b>	lubricating oils cut oils transformer oils recovered oils engine oils

**APPENDIX III CAUSTIC CASCADING SYSTEM**



**APPENDIX IV TYPE OF INCINERATOR VERSUS TYPE OF WASTE**

Typical Oil Content		Rotary Kiln	Multiple Hearth or Single Rotary Hearth	Fluidised Bed
30-100%	<b>Mainly Oil:</b> Waste oil, pumpable crude tank sludge	No	X	X
	Acid tar (N.B. consistency varies widely)	X or No	No	X
5-30%	<b>Medium Oil Content:</b> (after pre-treatment and homogenisation)			
	Gravity separator and desalter bottom sludges			
	a) if pumpable b) if too solid to be pumpable	X Yes	X Yes	Yes No
	Recovered oil tank interface sludge	No	No	X
0-5%	<b>Low Oil Content:</b> (after thickening and/or dewatering) Flocculator and/or excess biological sludge	X	Yes (X)	Yes
Solids		Yes	Yes	X
Oily earth		Yes	No	No
Oily stones etc.		X	No	No
Bitumen		Yes	X	No
Oily rags etc. or domestic refuse		Yes	X	No

X= Not really suitable but can accept moderate quantities with care if the type of incinerator has been chosen primarily for a different type of waste.