

INTRODUCTION

1. Oils originating from petroleum crude can be processed, blended and formulated to produce numerous ranges of products for many applications. Users of oils and oil products include not only industrial and commercial interest, but by virtue in particular of lubricants and fuel oils, the individual citizen. This can have profound affects on waste disposal issues.
2. The principal uses of oils are as fuels, lubricants, hydraulic and transmission fluids, heat transfer fluids and insulants. As fuels, oils cover a wider spectrum from light, highly mobile liquids, to heavy fuel oils of such low viscosity at ambient temperatures that they must be heated to enable their use. Lubricants embrace an even wider spectrum of products with many different viscosities and viscosity ranges, and the extensive use of performance enhancing additives. Similarly with the other broad categories, a very high degree of product specificity can be introduced to match precisely defined needs, via both the primary refining itself, and subsequent blending and formulating.
3. Users of oil and oil products include, to some degree at least, almost all industrial and commercial sectors, and many individuals and households. The transportation industry is a major user of oil both as a fuel for aircraft, shipping and many land-based transport systems, but as lubricants for the propulsion engines themselves. Motor vehicles of modern design many have several different non-fuel oil applications, such as engine crankshaft lubrication, gearbox lubrication and hydraulic fluids for brake systems. Motor vehicles, and their use, impinge on most aspects of life. Oils as fuels are one of the major energy sources for electricity generation, particularly smaller and more localized installations, and for fuelling district heating and hot water schemes at levels above base-load. Any production, manufacturing or process industry using fixed equipment with moving parts will have some use of oils, but engineering industries with metal cutting and finishing activities could be heavy users.
4. As has already been observed, oil and oil products are associated with many aspects of everyday life, and all can to some extent generate wastes. From the control and management point of view however, the most important waste sources can be identified reasonably easily, and this is done either because of their size, or because of special problems which they may pose.
5. Oils themselves are not especially toxic, although contaminants such as additives, breakdown products, and other substances which may have become mixed with oils during their legitimate use, may be much more so. Oils do however have considerable potential to cause environmental damage by virtue of their persistence and their ability to 'spread' over large areas of land or water. Films or coverings of oil substances may reduce or prevent air from reaching life forms of all types within an area of land or sea, and can rapidly result in significant degradation of environmental quality in those media. Waste acid sludges arising from the acid/clay process - a common method of recycling waste oils - represent a serious environmental threat. Such method of recycling requires the same level of vigilance as for hazardous wastes.

Sources of waste oils and oil bearing wastes

6. A major and continuing source of waste oils is from lubrication. Lubricating oils need replacing at intervals, and whilst improved designs of engines and better oil grades may reduce the frequency of change, there is little prospect of the need for oil changes being avoided altogether. Major contributors to this market will be motor cars, commercial vehicles, aircrafts, railway locomotives and other major items of machinery. Oils from these sources will usually contain not only contamination from their use, but a variety of additives intended to improve performance.

7. Machining or cutting oils are used extensively for metal cutting, machining of components on lathes and general engineering activities. In many instances, depending on the metal being machined, oils for this purpose are used as an emulsion in water with detergents, biocides, chlorinated paraffins, halogenated and non-halogenated additives, and additives included to improve performance. The waste, the arisings of which can be substantial in volume, comprises an emulsion of typically 2-5% oil in water. The waste also may contain metal dusts, swarf, and similar contamination.

8. Tank washings and sludges from storage tanks and refineries which include those from the cleaning of oil storage tanks can contain breakdown products. Also, tank washings including marine wastes collected under the provisions of the Marpol Convention, can generate substantial volumes of waste, usually with medium to low oil contents. Typically sources would be oily bilge water, oily ballast water, water from the jetting and cleaning of tanks both on board ships and at land-based installations, and true tank-cleaning residues. The range of oils encountered in the generation of these wastes can be broad, and can include accumulated oil sludge and sediment, tank scale and even grit from grit blasting and related cleaning work.

9. Electrical power equipment, including transformers and capacitors, use particular grades of oils having low water absorption properties suitable for electrical insulation and heat transfer. In the ordinary course of events, oil used in such equipment will not need to be changed on a routine basis during the lifetime of the equipment, some equipment is "sealed for life". Special care and attention must however be given to wastes arising from such equipment, since alternative non-oil materials may have been used in some applications, these materials having quite different properties, and requiring a whole different regime of control and disposal.

10. Particular concern centres on a family of substances known as polychlorinated biphenyls (PCBs) which combine excellent insulation and heat transfer characteristics, with high stability and non-flammability. However they are environmentally extremely persistent and bio-accumulative, toxic (and a suspected carcinogen), and if burned under unsuitable conditions, will give rise to toxic products of combustion including dioxins and dibenzofurans. A number of national and international legislation agencies have developed regulations aimed specifically at this sector, and involving registration, cataloguing and routine inspection of this equipment. In some cases, this has also featured an accelerated withdrawal programme requiring equipment owners either to replace the equipment with a non-PCBs equivalent at a date earlier than its normal replacement, or to replace the PCBs

liquid in the existing units. This latter practice can itself result in problems, in that the internal design of equipment such as transformers makes it difficult to remove all the PCBs, even if at a flushing stage, involving some other solvent is employed. Refilling of the transformer with another fluid (also known as 'retrofilling') can result in that fluid becoming contaminated with PCBs to an extent that it could prejudice the otherwise safe eventual disposal of that fluid. Great care is therefore required in assessing and selecting disposal options for oils derived from electrical equipment. (For details on wastes comprising or containing PCBs refer to "Technical Guidelines on Wastes Comprising or Containing PCBs, PCTs, and PBBs" SBC No. 97/009)

11. There are many more specialized oils used in specific applications, and which ordinarily will not need frequent, if any, changing during the lifetime of the equipment in which they are used. Waste arisings of these categories therefore tend to be small.

Options for management of wastes

12. In general with all waste management options, there are preferred choices and hierarchies of options. Waste avoidance/minimization is the preferred choice in all appropriate cases, this including the substitution of substances by others which generate less hazardous waste. Recovery and recycling of wastes provide the next range of preferences, followed finally by those involving outright disposal.

13. As will be apparent from earlier descriptions of waste sources, oil wastes will tend to fall into one of two categories - high oil/hydrocarbon content materials, and mixtures of oil and water in which water is the major portion including emulsions. Similarly, options for dealing with wastes tend to group into those appropriate for the high oil content materials where recovery and reuse opportunities exist, and the aqueous mixtures needing some other treatment of pre-treatment approach, albeit with the possibility of subsequent reuse of a recovered fraction.

14. Waste oils with high oil contents clearly have considerable energy potential, and will be seen by many as having the potential to be used as a fuel substitute. The use as fuel of unprocessed waste oils is subject to some controls and restrictions in a few countries, but generally is not prohibited. Large quantities of waste oils therefore are used as substitute fuels, substituting for virgin fuel oils of approximately comparable characteristics. Such practice can affect the viability of alternative, recovery options, by establishing a market value for waste oils at a little below the cost of virgin material. This can render uneconomic processes such as re-refining of lubricating oils.

Waste Avoidance and Minimization

15. The nature and properties of oils, and the uses to which they are consequently put, makes it unlikely that those uses can be eliminated or avoided altogether. However, improved efficiencies and practices in all areas in which oils are used should lead to significant reductions in waste generation. Improvements in the design and performance of engines result in reduced oil change frequencies, and hence a reduction in the generation of waste from these sources. However, there is an ever increasing number of engines being used.

16. Oil water mixtures from marine and shorebased storage tank cleaning and washing arise because of unavoidable or unplanned activities. Plants and procedures can be optimized so as to minimize the quantities of waste produced, such as using oil/water separation and recycling/reuse of water. Oil/water mixtures and in emulsion form, such as cutting oils described in paragraph 7, also can be reused to some extent, thus reducing quantities requiring disposal. Simple settlement and filtration of the used material, so as to remove abrasive material usually allows reuse many times over.

17. Oils contaminated with PCBs require special consideration. These will arise from the retrofilling of former PCBs containing units with non-PCBs substitutes, and the subsequent contamination of the substitute material by traces of PCBs remaining in the unit. It is difficult to avoid some degree of such contamination with retrofilling activities, and for this reason some authorities discourage retrofilling altogether, and seek the disposal of PCBs containing equipment and its replacement with new, non-PCBs units. Where retrofilling does take place, the need for disposal of the contaminated substitute fluid will depend upon national legislation, and the concentration of PCBs. Mineral oil used in transformers which has become cross contaminated by PCBs during processing (as a result of bad house keeping) represent a large volume of waste in this category. Processes exist for the destruction of PCBs in oils, without impairing the oil itself, and without generating significant quantities of waste.

Recycling and Recovery

18. Generally, waste oils can be recovered and recycled, either directly in the case of high oil content wastes, or after some form of separation and concentration from high aqueous content materials. While certain types of waste oils, lubricants in particular, can be subjected to regeneration processes which give products of comparable quality to the original material, a large volume of waste oil is used for its energy content, as a secondary or substitute fuel.

19. Waste oils, by the nature of their use, will contain various contaminants including heavy metals, combustion by-products and substances arising from the original use (e.g. PCBs). **Regeneration processes** include steps for separation/removal of such contaminants either prior to, or as part of the overall regeneration activity. Contaminants removed in this way will become part of waste streams which must themselves be disposed in an environmentally sound manner, having full regard to relevant legislation and standards.

20. Several regeneration technologies exist, but all are comparatively expensive to operate when all safety and environmental considerations are included. Generally therefore, regeneration processes are unable to establish economic viability unless some constraints exist on the use of waste oil as a fuel (a few countries have such controls), or the oils are of a highly specialized and valuable nature, and merit regeneration on that account.

21. Apart from economic considerations, oil regeneration technologies depend to some degree on quality of waste oil and particularly in there not being significant concentrations of difficult oil products such as heavier fuel oils. The presence of such materials can seriously disrupt the technical performance of the regeneration process, and its ability to produce lubricating or similar products of sufficiently good quality.

22. All regeneration processes involve the application of reasonably sophisticated technology, and require care and expertise in their operation. TABLE 1 below indicates some features of these processes in terms of their energy requirements, waste generation characteristics, process chemical needs etc.

Table 1

Evaluation Item	Acid/Clay	Vacuum Distillation/Clay	Vacuum Distillation/ Hydrotreating
1. Lube yield ^a	Low	Medium	Medium
2. Bright stocks ^b	Recovered	Lost	Lost
3. Utilities ^c	Low	Low	High
4. Overall energy ^d	High	Low	Medium
5. Hazardous chemicals ^e	Sulphuric Acid	Caustic	Caustic
<i>Waste Streams</i>			
6. Acid Sludge	Most	None	None
7. Oily Clay	Most	Some	None
8. Caustic sludge or spent caustic	None	Some	Some
9. Process water	Low	Medium	High

^a **Lube yield:** The oil yield in the acid/clay process is low because of losses to the acid sludge. The two distillation processes do not recover bright stocks and this is reflected in their moderate lube oil recovery.

^b **Bright stocks:** Bright stocks are recovered only in the acid/clay process. This process would be favoured in the unusual situation where used oils contain extremely high proportions of bright stocks.

^c **Utilities:** 'Utilities' refers to the total external energy requirement (power plus fuel).

^d **Overall energy:** This is total external energy (utilities) plus potential energy lost in non-recovered oils.

^e **Hazardous chemicals:** In the acid/clay process, the operators are exposed to the risk of handling sulphuric acid and the resulting acid sludge. All three processes expose the operators to possible chemical burns.

23. As the next option to regeneration, recovery of oils centre principally upon its use as a *fuel*. The inherent high energy content of some waste oil streams may encourage their direct use as fuels, without any pre-treatment and processing, and without any quality control or product specification. Such direct uses do not constitute good practice, unless it can be demonstrated that combustion of the waste can be undertaken in an environmentally sound manner.

24. Normally, waste oils for use as fuel need to be subjected to at least rudimentary treatment involving some form of settlement to remove sludges and suspended matter. Simple treatment of this type can improve substantially the quality of the material by removing sludges and suspended matter, heavy metals and carbon.

25. Although much waste oil used as a secondary fuel receive only such basic pre-treatment, every encouragement should be given to measures which improve the quality and control of this type of activity. Where fuels are to be marketed broadly it is certainly desirable that waste oils are subjected to both source and quality screening, and that products are supplied to a specification, even if only rudimentary. Where activities of this type are subject to a licence, permit or authorization system, conditions should be specified to ensure that a minimum level of control is established, and that equipment for blending, separation etc. is provided, used when necessary and maintained properly.

26. The fact that waste oil can often be readily used as a substitute fuel oil will tend to give it a market value a little below premium quality new fuel oils. That market value will apply equally to oils which could be subjected to regeneration processes, thereby establishing what is in effect a minimum raw material feedstock price for regeneration processes. Regenerated products such as lubricants cannot usually command prices higher than premium quality new materials - in fact they would usually sell for somewhat less. Thus, regeneration processes are constrained both by feedstock and product prices dictated by oil product prices generally, and the margin between feedstock costs and product income must cover the total regeneration process costs if the activity is to be economically viable.

Treatment and Disposal Options

27. It is most unlikely that high oil content wastes will not be subject to some reuse or recovery type use although great care must be applied to those containing PCBs. However, many oil wastes are highly aqueous in nature, and are not amenable to direct recovery. Such wastes must first be subject to **treatment** to separate the waste into an oil rich fraction which may be usable in some way, and an aqueous waste stream which may require further treatment prior to final disposal. Processes of this type usually yield sludges which, along with other oil waste based sludges, have no beneficial use and will require final disposal.

28. Non-emulsified oil-water wastes may be separated by simple gravity based equipment such as interceptors, or by the use of heat and/or salts dissolved in the aqueous effluents will usually require some further treatment prior to final disposal of the liquors. Such treatment will depend upon the nature and source of the original waste, and this should be established in each case. Separation using methods which rely on gravity are rarely sufficiently efficient to remove oil from the aqueous phase sufficient to allow its discharge to rivers, the sea, or public sewers.

29. Emulsified oils, sometimes stabilized by the presence of particulate, require more elaborate treatment. In some cases emulsions can be broken by acidification of the mixture. Membrane technology, such as ultra-filtration can separate water from an oil rich waste stream. Such plants have been operated on a successful commercial basis. Centrifuges of various types can also provide means of separation, including emulsions. In all cases, the oil rich stream can be subjected to further clean up processes to allow its reuse, whereas aqueous and sludge wastes are unlikely to have any value, and will require disposal. Aqueous wastes are unlikely to be entirely free from oil and may need further treatment on that account. Also, aqueous wastes may contain other contaminants, depending upon the original process, including surfactants, solvents and toxic metals.

30. The presence of PCBs in waste oil as a secondary fuel presents the risk of the production of harmful products of combustion such as hydrochloric acid, but particularly dioxins and dibenzofurans. Several legislative arrangements have been put in place in individual countries which seek to define the concentration of PCBs in waste oil below which no concern need be felt. Figures of 50ppm are fairly well established in respect of marketing and use. There is however a consideration within the European Community to reduce this to 20 ppm to make consistent with the limit on oils being used as fuel.

31. Processes exist for treating oils from transformers and similar equipment which have become contaminated with significant levels of PCBs - typically a few hundred to several thousand ppm. These processes are based on a chemical dechlorination of the PCBs by use of powerful reagents such as sodium. The reagent does not affect the basic oil itself, but breaks down the PCBs, generating a residue which may be removed by physical separation. In the hands of expert contractors, such technologies can be carried out even whilst a transformer is in use and operating.

32. **Incineration**, with or without energy recovery provides a preferred final disposal option for oil wastes - solid, liquid and sludge - which cannot for technical or commercial reasons be recovered. In the case of waste oils containing levels of PCBs above a defined level, and which do not merit application of clean-up technologies, incineration is the preferred and recommended form of final disposal.

33. Whilst many oil products are burnt without the application of clean-up technologies to the combustion gases, this may well not be acceptable for oil wastes. Such wastes may contain heavy metals, chlorinated or sulphonated contaminants, or particulate matter which would not easily burn. Incineration of such materials is likely to require emission control/gas cleaning equipment to achieve environmentally sound emission standards.

34. **Landfill sites**, even when specially engineered to high standards, and with advanced controls on leachate, gas generation must be carefully evaluated by national authority for their suitability for the disposal of oily wastes in bulk. Landfill may however be appropriate for some thick, semi-solid or solid sludges, tarry residues, tank and cleaning scale, particularly if subjected to a solidification process. This can also be the case where there are minimal quantities of oils in small containers such as can be present in household/municipal waste. In some cases, such as in containment sites and depending on site characteristics and absorptive and biodegradable potential, landfill may be acceptable for highly aqueous oil containing wastes. In all such cases, great care is needed and landfill licenses and permits may be needed to ensure that such activities can be undertaken without harm to man and the environment.