BASEL CONVENTION TECHNICAL GUIDELINES ON USED OIL RE-REFINING OR OTHER RE-USES OF PREVIOUSLY USED OIL

Basel Convention on the Control of Transboundary Movements on Hazardous Wastes and Their Disposal

No. 5

UNEP

BASEL CONVENTION
ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF
HAZARDOUS WASTES AND THEIR DISPOSAL

UNEP

SECRETARIAT

TECHNICAL GUIDELINES ON USED OIL RE-REFINING OR OTHER RE-USES OF PREVIOUSLY USED OIL (R9)

Revised Version
These Technical Guidelines were prepared by the
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Basel Convention
Technical Guidelines on Used Oil Re-Refining of Other Re-Uses of Previously Used Oil

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Foreword

These technical guidelines are principally meant to provide guidance to countries who are building their capacity to manage waste in an environmentally sound and efficient way and in their development of detailed procedures or waste management plan or strategy. They should not be used in isolation by the competent authorities for consenting to or rejecting a transboundary movement of hazardous waste, as they are not sufficiently comprehensive for environmentally sound management of hazardous waste and other waste as defined by the Basel Convention. These technical guidelines concern waste generated nationally and disposed of at the national level as well as waste imported as a result of a transboundary movement, or arising from the treatment of imported wastes.

It is necessary to consider this document in conjunction with the Document on Guidance in developing national and/or regional strategies for the environmentally sound management of hazardous wastes (SBC Publication - Basel Convention Highlights No. 96/001 - December 1995) adopted by the second meeting of the Conference of the Parties. In particular, special attention should be given to the national/domestic legal framework and the responsibilities of the competent authorities.

These guidelines are meant to assist countries in their efforts to ensure, as far as practicable, the environmentally sound management of the wastes subject to the Basel Convention within the national territory and are not intended to promote transboundary movements of such wastes.

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I. INTRODUCTION

1. The processing of used and waste oils has been practised for many years, with organised recycling of engine lubricating oil from vehicle fleets being well established by the 1930s. Certain waste oils streams arising on oil refinery sites have been fed into so called "crude ponds" and as part of material which was accumulated in these have been recycled.

Used oil

2. In the context of these guidelines used oil means any semi-solid or liquid used product consisting totally or partially of mineral oil or synthesised hydrocarbons (synthetic oils), oily residues from tanks, oil-water mixtures and emulsions. These arising from industrial and non industrial sources where they have been used for lubricating, hydraulic, heat transfer, electrical insulating (dielectric) or other purposes and whose original characteristics have changed during use thereby rendering them unsuitable for further use for the purpose for which they were originally intended.

3. Synthetic oils may cover a wide range of chemicals, but are generally found within the following categories:

- synthetic hydrocarbons;
- hydrocarbon esters;
- phosphate esters;
- glycols;
- chlorinated hydrocarbons;
- silicon oils.

Synthetic hydrocarbons are similar in composition to those found in petroleum base oils, but they are synthesised using chemical processes in which basic carbon and hydrogen compounds are combined. Generally, they are incorporated into oils to impart to the finished product enhanced levels of the properties possessed by the petroleum distillate feed stocks.

4. Hydrocarbon esters are reaction products of organic acids and alcohols and encompass a wide range of products. Phosphate esters are products obtained by reacting phosphoric acid and alcohols. Esters used in lubricants are usually thermally stable to quite high temperatures. Glycols, are polyhydric alcohols which, like esters, contain oxygen and comprise a wide range of compounds including ethylene glycol, used to lower freezing points, and complex poly-glycols. They provide extreme pressure resistance to highly loaded gear applications.

5. Reducing the use of lead additives in gasoline/petrol used in motor vehicles has been quite effective in diminishing, over time, the lead content in used motor oil. This has proven to be a very significant and efficient way to minimize the risks of used motor oil, particularly used oil burned for energy where lead emissions are often of concern.

Why oils are recycled or re-used

6. The management of used oil is particularly important because of the large quantities generated globally, their potential for direct re-use, reprocessing, reclamation and regeneration and because they may cause detrimental effects on the environment if not properly handled, treated or disposed of. Used lubricating and other oils represent a significant portion of the volume of organic waste liquids generated worldwide. The three most important aspects of used oils in this context are: contaminant content, energy value and hydrocarbon properties.

7. Used oil, as referred to in these technical guidelines, is an oil from industrial and non-industrial sources which has been used for lubricating or other purposes and has become unsuitable for its original purpose due to the presence of contaminants or impurities or the loss of original properties (e.g. lubricating oils; hydraulic fluids; metal working fluids , electrical (dielectric) or heat transfer fluid, insulating fluid).

Used oil primarily contains hydrocarbons. It may also contain additives, (i.e: lead) and impurities due to physical contamination and chemical reactions occurring during its use. Contamination of used oil may also occur from mixing it with other oily fluids or liquid wastes; such contamination may seriously prejudice recovery or recycling operations.

8. Recycling. This is the commonly used generic term for the reprocessing, reclaiming and regeneration (re-refining) of used oils by use of an appropriate selection of physical and chemical methods of treatment.

9. Reprocessing usually involves treatment to remove insoluble contaminants and oxidation products from used oils by heating, settling, filtering, dehydrating and centrifuging, etc. Depending on the quality of the resultant material this can be followed by blending with base oils and additives to bring the oil back to its original or an equivalent specification. Reprocessed oil is generally returned to its original use.

10. Reclamation. This usually involves treatment to separate solids and water from a variety of used oils. The methods used may include heating, filtering, dehydrating and centrifuging. Reclaimed oil is generally used as a fuel or fuel extender.

11. Regeneration. This involves the production of base oils from used oils as a result of processes which remove contaminants, oxidation products and additives i.e. re-refining involving the production of base oils for the manufacture of lubricating products. These processes include pre-distillation, treatment with acids, solvent extraction, contact with activated clay and hydrotreating. They should not be confused with the simpler methods of treating oils, such as those given under reclamation.

Scope for recycling

12. A large range of used (waste) oils can be recycled and recovered, either directly in the case of high oil content wastes, or after some form of separation and concentration from high aqueous content materials. Certain types of waste oils, lubricants in particular, can be processed allowing for direct reuse. The use of waste oils after treatment can be either a high

energy content, clean burning fuel or a lube base stock comparable to a highly refined virgin oil.

13. Reclamation of used oils can give a product of comparable quality to the original, but may contain various contaminants depending on the nature of the process such as heavy metals, by-products of thermal breakdown and substances associated with specific uses (e.g. lead, corrosion inhibitors, PCBs). The regeneration of used oils is widely practiced to obtain the highest degree of contaminant removal leading to the recovery of the oil fraction which has the maximum viable commercial value.

Sources of used oils

14. Used oils originate from diverse sources. These include petroleum refining operations (including sludges containing appreciable amounts of oil originating from the various parts of petroleum plants such as sumps, gravity separators, and the cleaning of storage tanks), the forming and machining of metals, small generators (do-it-yourself car and other equipment maintenance) and industrial sources, and the rural farming population. Collecting used oil from non-industrial sources and local/small generators is very difficult and requires a well established and efficient infrastructure to accomplish the task. In this regard, it is important to develop adequate reuse or recycling options, to properly handle the collected volume of oil, to address the specific properties of the concerned waste and assess the degree to which used oils could be treated. A major source of oily wastes arising world wide is the sludge recovered from tanks used for the storage of leaded petrol. These sludges which are normally produced by high pressure water jet cleaning of storage tanks consist of iron oxide corrosion product and sediments, onto which organic and inorganic lead compounds have been ab/adsorbed mixed with fuel. The free fuel is usually readily removed by gravity or mechanical separation and used as an energy source. The highly toxic organic lead compounds associated with the sludge have to be chemically or thermally oxidised (calcined) to inorganic lead compounds to facilitate its disposal.

II. RECYCLING, REUSE AND RECOVERY

15. Used oils can be recycled or reused in a variety of ways. The first option in the waste management hierarchy is to conserve the original properties of the oil allowing for direct re-use . The second option is to recover its heating value (see Table 1). It is important, first of all, to recycle the hydrocarbon content of used oils. Re-refining could be seen as one of the preferred methods for disposal of used oil. It has the beneficial effect of reducing the consumption of virgin oils. However, it is very sensitive to the scale and the economics of the operation (for instance, thousands of tonnes per year of used oils would be required to sustain such a refinery operation).

A. *Reprocessing and re-refining*

16. Reprocessing and re-refining involve operations which will separate and remove contaminants in used oil so that this oil becomes suitable for reuse. Contaminants removed in this process will be part of waste streams which must be disposed of in an environmentally sound way.

17. In reprocessing, relatively simple physical/chemical treatments such as settling, dehydration, flash evaporation, filtration, coagulation and centrifugation are applied to

remove the basic contaminants in used oils. The objective is to clean the oil to the extent necessary for less demanding applications, not to produce a product comparable to virgin oil. Direct reprocessing is not feasible for mixed oils; therefore, at source, segregation of used oil stocks is essential. Reprocessed oils are most commonly used in industrial applications.

18. Re-refining requires modern processes which are expensive to operate when all safety and environmental considerations are included into the overall operating system. In the re-refining process a continuous feed of used oil is heated and in stages it is de-watered and vacuumed distilled into separate grades of distilled oil. These oils may be then hydro-treated to produce a fine clear product. The by-products which have marginal value include distillation bottoms (used as an asphalt extender or in fuel oil blending) and demetallized filter cakes (used as road base material). The remainder of the materials are residues or waste streams such as acid tar, spent clay, centrifuge sludge and process water that are directed to treatment and/or disposal.

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

20. All regeneration processes involve the application of reasonably sophisticated technology, and require care and expertise in their operation. Table 2 indicates some features of these processes in terms of their energy requirements, waste generation characteristics, process chemical needs, etc.

21. It must be noted that re-refining processes may, in certain cases due to their high costs, not be viable on economic grounds. 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 which are 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. This process will produce wastes that have to be disposed of and the disposal costs of the residues could represent a significant proportion of the total costs. However, regeneration could reduce the amounts of waste going to final disposal, with significant economic benefits.

22. In addition, although the technological capabilities of the rerefining industry allow most used oils to be regenerated, some limitations on used oil feedstock are necessary. Table 4 indicates used oils commonly re-refined by the Canadian Association of re-refiners. Finally, the oil yield and quality differ in relation to the technology employed. The three most commonly used re-refining technologies in respect of aiming at ensuring optimal product yield, meeting utility and energy requirements, limiting hazardous chemicals used and waste volumes produced are:

- the acid/clay re-refining process;
- the vacuum distillation/clay process;
- the vacuum distillation/hydrotreating process (hydroprocessing).

23. The acid/clay process has a long operational history, it is not highly sophisticated and is appropriate to a wide range of circumstances and is thus readily operable in most countries. However, a number of studies made on ranking of re-refining by-product waste streams in terms of environmental hazards suggest that the acid/clay process is the least environmentally sound of the three main re-refining processes. The principal reason for this is the large quantity of by-product acid tar produced which presents difficulties in disposal. It is therefore highly recommended not to use such a process in case there is no or inadequate capacity or facility to treat and dispose of the acid sludges resulting from the process. Vacuum distillation involves the distillation of oils under sub-atmospheric pressure which lowers the necessary operating temperature and reduces problems of thermal breakdown. The use of wiped film equipment which allows material with significant solid contents to be more readily processed with reduced thermal breakdown is increasing. Clays with high adsorptive capacity are used to remove impurities such as heavy metals and breakdown products arising in the use of oil. They are frequently used before distillation to provide a cleaner feed and also to give recovered oil a final polish.

24. If there was a more economically and environmentally sound way for treating acid tar, the overall process could then be operated in a more efficient way. Technical solutions to many of these problems have been developed and are being increasingly applied, however the commitment of additional resources are seen as necessary to the rapid further commercialisation of existing development and to identify new management methods to overcome the environmental problems of the disposal of acid tar.

25. Catalytic treatment (hydroprocessing) of used oils provides a commercially viable alternative to high temperature incineration or chemical treatment. Selective hydrogenation could be utilized to remove contaminants such as PCBs or heavy metals from used oils. Catalytic hydrogenation of contaminated organic waste streams is carried out at moderate temperatures and pressures. The treated organic phase is generally suitable for reuse as a fuel oil. The use of this technology is primarily constrained by economics, though disposal costs of organochlorine-contaminated oils could be substantially reduced. Thus the use of this type of technology could have positive economic benefits.

See Tables 1 and 2 on pages 6 and 7 respectively

TABLE 1

Distillation/Hydro Evaluation Item	Acid/Clay	Clay	Distillation/Treating
1. Lube yield[a]	Low	Medium	Medium
2. Bright stocks[b]	Recovered	Lost	
3. Utilities[c]	Low	Low	High
4. Overall energy[d]	High	Low	Medium
5. Hazardous Chemicals[e]	Sulphuric Acid	Caustic	Caustic
Waste streams			
6. Acid sludge	Most	None	None
7. Oily Clay	Most	Some	Some
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, some degree of sulphonation taking place. 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 concentrated sulphuric acid and the resulting acid sludge. All three processes expose the operators to possible chemical burns.

Source: Rudolph, 1978

TABLE 2[1]

USED OILS COMMONLY REREFINED BY THE CANADIAN ASSOCIATION OF REREFINERS

Re-refinables (complete list)	Non-Re-refinables (partial list)
High Viscosity Index (HVI) Oils All diesel and gasoline crankcase oils	Oils Containing Polychlorinated Biphenyls (PCBs) and Polynuclear Aromatics (PNAs)
Transmission oils	LVI and MVI oils
Hydraulic oils (non-synthetic)	Halides
Gear oils (non-fatty)	Synthetic oils
Transformer oils (non-PCBs)	Brake fluids
Dryer Bearing oils	Fatty oils
Compressor oils	Asphaltic oils
Turbine oils	Black oils
Machine oils (non-fatty)	Bunker oils
Grinding oils (non-fatty)	Metal working oils containing fatty acids
Quenching oils (non fatty)	Form oils Rolling oils Solvents of any type

Source: CCME - Code of Practice for Used Oil Management in Canada, August 1989

It is the Secretariat's understanding that:

a) The list should include heat transfer oil
b) Non Re-refinables applies for original use
c) PCBs re-use is prohibited in many countries already

[1] A number of these oils may contain halogenated organic materials as well as metals that can lead to serious health and environmental problems if re-refining is done with inappropriate or lower technologies or processes.

B. *Recovery (controlled burning)*

26. The next option after re-refining is the recovery of oils focusing principally upon its use as a fuel. A large volume of waste oil is used solely for its energy content, as a secondary or substitute fuel (under controlled combustion conditions). The inherent high energy content of many used oil streams may encourage their direct use as fuels, without any pretreatment 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. The use of waste oil as fuel is possible because any contaminants do not present problems on combustion, or it can be burnt in an environmentally sound manner without modification of the equipment in which it is being burnt. Normally, used oils for use as fuel need to be subjected to treatments involving some form of settlement to remove sludges and suspended matter. Simple treatment of this type can substantially improve the quality of the material by removing sludges and suspended matter, carbon and to varying degrees heavy metals.

27. Although much used oil used as a secondary fuel receives 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 used 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 as necessary and maintained properly.

28. The partial replacement of fuel with used oils is a technique that is widely applied around the world, in particular under controlled conditions in cement kilns. Other uses as fuel include: in stone quarries for stone drying purposes or in asphalt coating plants, in smelters handling iron, lead, tin, aluminium and some precious metals. Also as support fuel in chemical incinerators, in coking plants, in brickworks, electricity generating stations and steam raising boilers.

29. Most oil-fired domestic, commercial, industrial or utility boilers can burn used oils. However, combustion of used oils not the subject of strict product specifications or under uncontrolled conditions can lead to serious pollution of all environmental media. Also, combustion plants will suffer corrosion when oils with halogen contents are burnt. Large industrial and utility boilers are generally considered to pose relatively low environmental risks because of their combustion efficiency, use of consistent quality fuel, and in some cases pollution control devices (e.g. electrostatic precipitators, bag filters, high energy venturi scrubbers), tall dispersive chimneys, and their location (often away from high population densities).

30. The environmental risks associated with burning used oil in any size boiler could be reduced through the application of comprehensive and integrated management strategies including:

- pretreatment of used oil to meet established quality specifications (e.g. settling, centrifugation, vacuum distillation, solvent extraction);

- dilution of used oil by blending with virgin fuels[2];
- installation of flue gas emission control devices.

31. It must be noted that used oil can be burned in cement kilns without many of the negative air quality effects normally associated with burning used oil in small- to medium-sized boilers. Unless boilers or other combustion processes are equipped with burners of high combustion and contaminant destruction efficiencies or with flue gas treatment devices, used oil burning should be strongly discouraged or prohibited if practicable. This implies that efforts should be made to bring adequate treatment and/or disposal technologies to remote communities and sparsely populated areas in need of such technologies and/or implement a programme providing the necessary infrastructure for establishing used oil collection/storage/transport/treatment system for such small volume oil generators.

C. *Other reuse practices*

32. Used oils have traditionally been directed to a variety of uses other than re-refining and burning; they are, for instance: road oil, raw material in asphalt production, flotation and forming oil, secondary lubricant, pesticide carrier, weed killer, livestock oil, all-purpose cleaner, and vehicle undercoating. Used oil, can also be introduced into oil refineries under certain conditions aiding the manufacture of other refined products.

Road oiling and asphalt production

33. Used oil has been applied to gravel roads as a dust suppressant for many years. It has been used most commonly in rural areas which have a high proportion of unpaved roads and are located some distance from other used oil markets (burning and re-refining). While some road oiling is still common in many areas of the world, its popularity has declined in recent years because of reductions in the proportion of unpaved roadways, problems due to contaminants in used oils (PCBs, PCDDs, PCDFs), competition from other used oil end uses (re-refining), availability of alternative dust suppression substitutes (calcium chloride, surfactants), and precluding environmental regulations. In fact, studies suggest that the potential impact generated by road oiling on health and the environment are severe enough to discourage or prohibit such practice. Road oiling with contaminated oil has lead to very serious environmental problems.

34. Used oils have been used occasionally as cutting stocks and extenders in the manufacture of asphalt. Since used oil constituents are essentially insoluble in water, potential contaminants are coated with viscous asphaltic materials and incorporated into the final product. Leaching of significant contaminant concentrations from finished asphalt roads and roofs is considered unlikely; however, the potential effects of using waste oils in asphalt production should be evaluated on a site or region specific basis. The hot coating of road stones with asphalt has given rise to environmental problems. This leading in certain circumstances to the setting of a 10ppm limit for PCB in used oil based fuels being used for this purpose. As a waste management practice, it should be discouraged. It does not impact significantly on the reduction of the volume of wastes that need to be disposed of. A number of countries are, in fact, prohibiting such a use.

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2 Dilution of used oil by blending with virgin fuels must be practiced with caution. Procedures for an exhaustive analytical determination of contaminants, possible dilution protocols, test runs with air pollution monitoring, collation of baseline information on plume distribution and meteorological conditions.

Miscellaneous end uses

35. The environmental effects associated with the other end uses listed earlier vary from one application to another. The nature and extent of concerns for any given application will depend on the volume of oil used, the operational practices of the companies or individuals involved, and the manner in which the oils are ultimately discharged to the environment. Generally speaking, these practices should be avoided unless it can be demonstrated that environmental risks can be effectively controlled on a site-specific basis.

III. ELEMENTS TO BE CONSIDERED FOR ENVIRONMENTALLY SOUND MANAGEMENT

36. Although some of the reuse and recycling alternatives are technically sound, the costs involved in the re-refining process and combustion of used oils can be very high. Source reduction, in this regard, should be seen as a primary objective in a strategy for hazardous waste management. It is also obvious that the economics of the reuse and recycling of used oils as a preferred option must be examined before considering final disposal. In certain circumstances however, for instance re-refining, may not provide an adequate return on investment. Viable and ecological sound alternatives should, in this particular case, be investigated before considering final disposal options. The direct burning of used oils in conventional combustion devices can create serious pollution problems and, although this can be reduced by fitting pollution abatement equipment, this is not, in most cases, very practicable. The burning in specially designed waste incinerators can diminish these problems; however, the process is very expensive, particularly if they do not provide for energy recovery.

37. In order to identify suitable and acceptable reuse and recycling options, a number of criteria need to be considered before deciding on which treatment technology to select; these include:

- the extent to which used oil can be treated to obtain specific products;
- potential of harm to human health and the environment;
- economic balance and market opportunities;
- transport requirements/costs;
- location of treatment facilities;
- processing of the hazardous waste contaminants and by-products of the process itself;
- worker safety.

38. The question as to which treatment technology is most appropriate is *de facto* related to regulations, availability of facilities and their location, and in most cases to a significant degree on the market mechanism (competitive uses of the products). Table 5 provides examples applying to lubricating oils.

39. Any decision process used to select a preferred recycling or reuse option must take into account the fact that the matter needs to be dealt with by experienced professionals and waste managers. A critical assessment must be made of a number of factors before arriving at a decision. The contaminants and environmental/health risks associated will ultimately limit the number of acceptable reuse or recycling options of used oils. Equally, the availability of waste management resources (collection, storage, transport and treatment) will restrict the selection of environmentally sound disposal options (including blending, segregation, gravity separation, strategic storage for the preparation of optimal feed stock blend, etc.). Finally,

economic viability (which will be affected by: transport costs; end uses; pollution abatement investment; etc.), social acceptability considerations as well as regulations (regulations and other economic instruments could be developed and implemented to assist in sustaining the market) would form part of the analytical procedure.

40. Therefore, basic criteria for the selection process of environmentally sound reuse or recycling options of used oils should be based, *inter alia*, on the following considerations:

- *Feedstock (upstream) quality*: degree and nature of contamination and environmental/health risks associated with handling and processing, volumes and types.

- *Treatment processes* for getting appropriate quality feedstock for downstream industries or users, impacts on resource conservation, percentage of the product recovered, energy savings.

- *Impacts of treatment processes* on public health and environmental media.

- *Final disposal* of end-of-the-pipe output of treatment processes in the framework of environmentally sound management of hazardous wastes.

- *Economics* (economic viability/sustainable market and commercial feasibility; product value).

- *Technology and techniques* (treatment capacity, feedstock capability) and their potential impacts on the environment.

- *Location* of existing or planned facilities.

- *Infrastructure* for clean and efficient collection, storage, and transport of used oils.

- *Public perception*.

- *Legislation* (i.e. on air emissions).

- *Socio-economic benefits* (i.e. employment opportunities).

- *Knowledge of cases or processes* which have gone wrong in the past.

- *Availability* of cleaner production methods and clean technologies.

41. In some situations a number of supplementary factors need to be considered in the assessment procedure referred to above in order to comply with the requirements for environmentally sound and efficient management of hazardous wastes. For instance, in the case of transboundary movements, consideration of the standards for the environmentally sound management of the recovery operation in the State of export and the State of import should be looked into. Before getting into the authorization process for a particular reuse, recycling or recovery operation, the following elements should be taken into consideration: site selection, design standards for facilities, training of operators of the facility, environmental assessment, operation/discharge standards, monitoring and control, emergency and contingency plans, records and record-keeping, and decommission.

42. Further consideration should be given to the history of management practices, the preferred management methods for a particular waste stream, regulatory instruments, compliance with technical standards, enforcement requirements, etc.

43. Also, a number of elements should form part of the decision-making process, such as providing an assessment of the environmental soundness of affordable technologies; ensuring the existence of an adequate system for the analysis, monitoring and assessment of performance of the management infrastructure design to cope efficiently with the waste.

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Annex 1

TYPICAL SPECIFICATION FOR A WASTE OIL DERIVED FUEL

Density	(15"C)	0.875-0.92
Viscosity	(No.1 Redwood sec)	100-170
Calorific Value	(BTU/lb.)	18,500-19,250
Water	(%)	<3
Sulphur	(%)	0.5.-0.9
Lead	(ppm)	500-1,000
Flash point	("C)	75-90
Ash	(%)	0.4-1.0
Solids	(%)	0.5

Source: The U.K. Hazardous Waste Inspectorate - Third Report - 1988

Annex 2

SPECIFICATIONS FOR USED OIL

Constituent	*Allowable level*
Arsenic	5 ppm maximum
Cadmium	2 ppm "
Chromium	10 ppm "
Lead	100 ppm "
Total halogens	4000 ppm "
Flash point	100oF minimum

Source: U.S. EPA (1985 and 1992)
