Draft of the Modified

TECHNICAL GUIDELINES

ON THE VARIOUS USES OF USED OILS

AND THEIR RE-REFINING PROCESSES

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LIST OF ACRONYMS

ACGIH American Conference of Governmental Industrial Hygienists

AFR Alternative Fuel and Raw Material.

CPSC Consumer Product Safety Commission

EPA Environmental Protection Agency

FDA Food and Drug Administration

FFA Free Fatty Acids

HSDB Hazardous Substances Database

IARC International Agency for Research on Cancer

NIOSH National Institute for Occupational Safety and Health

OSHA Occupational Safety and Health Administration

PAH Polycyclic Aromatic Hydrocarbon

PCB Poly Chlorinated By phenyls

I.INTRODUCTION

1. The processing of used mineral oils has been practiced for many years. As a matter of fact, whilst the organized recycling of engine lubricating oil from various vehicle fleets is well established since the 1930s [1] yet, used vegetable oils, utilized for frying purposes, end up in the sewage system. Such disposal action that causes problems in the purification of urban waste water and consequently health problems. Other waste oils arising in oil refinery streams are usually accumulated and only some of them, that are recycled for processing, are usually fed into "crude ponds".

II. Used Mineral Oils

2. Mineral oils, which are manufactured from the refining of petroleum crude oils, consist of complex mixtures of straight and branched chain paraffinic, naphthenic, and aromatic hydrocarbons having 15 or more carbon atoms and having boiling points ranging from 300°C to 600°C. Actually, some higher boiling points have been reported for heavier oils. The complete description of a mineral oil must include the nature of the last treatment step, which determines whether the material is mildly or severely treated during the refining process [2, 3].

3. Medicinal white mineral oils are pharmaceutical- and food-grade materials- that are highly refined and free of all aromatic and unsaturated compounds. Because such products are highly refined oils, they are not covered under this listing.

4. Mineral oils are generally insoluble in water and alcohol but soluble in benzene, chloroform, ether, carbon disulfide, and petroleum ether. Whilst Mineral oils do not generally present any potential fire hazards, yet ignition can occur if they were preheated beforehand [4].

5. All crude oils contain some Polycyclic Aromatic Hydrocarbons (PAHs); in the base oils, the types and proportions of these compounds are primarily determined by the adopted Processes [5].

6. Virgin base oils are produced from oil refineries that have special high severity processing equipment that allows for the production of such highly refined and stable base oil products. These stable base oils are then blended with various additives to produce products that are specifically designed to lubricate or serve other very specific conditions- as given in Table [1].

7. Synthetic oils are manufactured from a wide range of chemicals that are generally found among the following compounds:

    - Synthetic hydrocarbons
    - Chlorinated hydrocarbons

- Hydrocarbon esters
- Phosphate esters
- Glycols
- Silicon oils.

8. Synthetic Hydrocarbons are similar in composition to those hydrocarbons that are naturally found in petroleum base oils; they are however synthesized using chemical processes that combine the basic carbon and hydrogen compounds. Synthetic hydrocarbons are generally incorporated into mineral oils, to promote the characteristic properties of the finished oil product that is produced from the petroleum distillate feedstock.

9. Hydrocarbon Esters are products resulting from the reaction of organic acids and alcohols and include a wide range of products. On the other hand Phosphate Esters are produced by the reaction of phosphoric acid and alcohols. Esters used, in lubricants are usually thermally stable to reasonably high temperatures. Glycols are polyhydric alcohols which, like esters, contain oxygen and comprise a wide range of compounds that include Ethylene Glycol which is used to lower the freezing points. Complex poly-Glycols provide extreme pressure resistance to gear applications that are generally subjected to high loads.

10. In 2004, the demand for motor oil worldwide amounted to 1.04 billion gallons, or about 42 percent of the total annual lube product demand.

11. Used Mineral Oils are defined as any oils that have been refined from crude oil, or any used synthetic hydrocarbon oil that has become unsuitable for their original purpose due to either the presence of impurities or the loss of their original properties as shown in Table 2. Consequently, it is important to note that, in the context of these guidelines, ***'Used oil'*** means any product that is liquid or semi-solid and consists totally or partially of Mineral oils or Synthetic oils, i.e.: (synthesized hydrocarbons). Such used oils arise from industrial and non industrial sources, following their use for lubrication or for hydraulic, heat transfer, electrical insulating (dielectrics) or for other purposes. Actually, the original characteristics of these used oil products generally change during their use; thereby rendering them unsuitable for further use in the job for which they were originally intended.

II.1 Why Oils Are Recycled Or Re-Used?

12. The Management of used oils is very important because of the large quantities that are globally generated. Such used oils have the potential for direct re-use, reprocessing, reclamation and regeneration; consequently, they may cause detrimental effects on the environment if they are not properly handled, treated or disposed of. Actually, used lubricating oils and other oils represent a significant portion of the volume of organic waste liquids that are generated worldwide. The three most important aspects of those used oils are:
   - Content of contaminants
   - Energy value

- Hydrocarbon properties.

13. Consequently, the term used oil, as referred to in these Technical Guidelines, refers to oil resulting from industrial and/or non-industrial source that has been used for lubrication or other purposes. Furthermore, such used oil has become unsuitable for use for its original purpose due to the presence of contaminants or impurities or the loss of original properties. N.B: Typical examples of such oils are: lubricating oils; hydraulic fluids; metal working fluids, electrical (dielectric) or heat transfer fluid, (i.e.: insulating fluid).

14. *Re-Refining:* There are many practical uses for used motor oil. The primary use is to re-refine it to a base stock for the manufacture of finished lubricating oils. Such Re-Refining process is very similar to the refining of crude oil. The resulting re-refined oil usually has a high quality as high as the virgin oil product. In fact, re-refining used oil takes from 50 to 85 percent less energy than the refining of crude oil. A secondary use of the Used Motor Oil is to produce heat energy; in fact, some large industrial boilers are able to efficiently burn the used oil with minimum pollution. Consequently, some of the used oil is sent to power plants or cement kilns to be burned as fuel. Finally, smaller quantities of used oils are burned in specially designed heaters to provide heating energy for small businesses.

15. It is important to note that, the volume of used oil that is burned is more than four times the volume that is re-refined, this aspect is inspite of the environmental benefits which favor re-refining because the toxic heavy metals (e.g.: zinc, cadmium, chromium, lead, and others) are extracted from the used oil. Actually, the re-refining process as when compared to combustion, have the advantage of separating the heavy metal compounds which are then solidified and subsequently stabilized into solids, thereby posing minimal Environmental Risk.

16. Combustion: In the Combustion Process, the metals in the combustion flue gases must be treated with air pollution abatement equipment prior to their release to the atmosphere. It is important to mention that combustion in cement kilns, steel mills, and other large-scale industrial combustion processes generally comprise 'state-of-the-art' Flue Gas Treatment Units that are effective in addressing the environmental issues.

17. To achieve Maximum Energy Conservation and Environmental Benefit, it is generally preferable to re-refine used oils into regenerated base oils, as compared to combustion, for the recovery of the heating value. The re-refined oil can then be blended with additives to manufacture finished lube oil products.

18. As mentioned above, the combustion of used motor oils in space heaters, does not result in similar levels of pollutant reduction. Actually, the environmental benefit of combusting used oil depends on the fuel that is displaced. Displacement of high environmental impact fuels like coal or petroleum coke would make combustion of used oils rank higher from an environmental perspective.

19. *Recycling* This is the commonly used generic term for the reprocessing,

reclaiming and regeneration (re-refining) of used oils, through the selection and use of appropriate or physical and chemical methods of treatment.

20. *Reprocessing*: This process usually involves the use of treatment operations to remove insoluble contaminants and oxidation products from used oils by such operations as heating, settling, filtering, dehydrating and centrifuging, etc. Depending on the quality of the resultant material required, such treatment operations may be followed by blending with base oils and/or additives to revert the oil back to its original or equivalent specifications. Actually, reprocessed oil is generally reverted back to its original use.

21. *Reclamation*. This operation 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. Reclamation can result in a product of quality that is comparable to the original oil, but may only contain various contaminants that depend on the nature of the process; such contaminants may be heavy metals, by-products of thermal breakdown and substances associated with specific uses (e.g. lead, corrosion inhibitors, PCBs).

22. *Regeneration*. This operation involves the production of base oils from used oils as a re-refining process wherein contaminants, oxidation products and additives are removed i.e. re-refining involves the production of base oils for the manufacture of lubricating products. Regeneration processes include the following aspects: pre-distillation, treatment with acids, Solvent Extraction, contact with Activated Clay and Hydro-treating. These operations should not be confused with the simpler methods of treating oils, such as those given previously under 'Reclamation'.

23. Reducing the use of lead additives in gasoline/petrol used in motor vehicles has been quite effective in eventually diminishing, the lead content in used motor oil. Such action has minimized the risks of utilizing used motor oils, particularly when burned for production of energy; this is because the health hazards from lead emissions to the environment are of lower concern. Industrial oils that have become unsuitable for the use in the job they were initially assigned include used oils from combustion engines, transmission systems, turbines and hydraulic systems as well as those from other different sectors of the car industry and the industrial shipping activities. Finally, in accordance with the current European regulations used mineral oils are classified as hazardous wastes because of their dangerous effects on both health and environment as will be discussed hereunder.

Effects of Used Mineral Oils on Health and Environment

24. Untreated and mildly treated Mineral Oils are known to be *human carcinogens*. The primary routes of potential human exposure to such mineral oils are inhalation, ingestion, and dermal contact. As a matter of fact, the general population is potentially exposed to Unused and Used Mineral Oils that are either naturally occurring or are present as contaminants in the environment.

25. Numerous studies have evaluated the carcinogenic exposure to mineral oils in a variety of occupations including metal working, newspaper press operation, and other newspaper work. Consistent exposure to mineral oils was strongly associated with an increased risk of skin cancers in many workers including metal workers. Actually, the Carcinogenic Effects on the prostate and lungs are due to the presence of lead, cadmium, manganese and other metals in such Minerals Oils.

26. Epidemiological studies (case-control, cohort, and proportional mortality studies) in metal workers have reported excesses of gastrointestinal, sinonasal, and bladder cancers in addition to skin and scrotal cancer. Some of those studies performed on workers in the printing industry have reported a visible increase in the occurrence or death incidences from cancers of the lung, rectum, buccal cavity, and pharynx. Accordingly, the International Agency for Research on Cancer (IARC) concluded that there was sufficient evidence for the carcinogenicity of Untreated and Mildly Treated Mineral Oils in humans [4,5]

27. Potential attack of cancer may occur as a result of occupational exposure to mineral oils can occur for workers employed in the manufacture of automobiles, airplanes parts, steel products, screws, pipes, precision parts, and transformers. Similar danger, may also affect workers employed in brass and aluminum production, engine repair, copper mining, and newspaper and commercial printing [4].

28. The Direct Effects of used mineral oils on the environment include the following: pollution of soils, rivers and the sea resulting from the low biodegradability of mineral oils. Actually, as used mineral oils come into contact with water, they produce a film that prevents oxygen circulation. Also, the uncontrolled combustion of such oils can lead to the emission of chlorine, lead and other gas elements into the atmosphere associated with their respective hazardous effects.

Sources of Used Oils

29. ***Used oils***. These originate from diverse sources including petroleum refining operations, the forming and machining of metals, small generators and other industrial sources in addition to rural farming population. Collecting used oils from non-industrial sources and local/small generators is very difficult and requires a well established and efficient infrastructure to accomplish that task. In that respect, it is very important to develop adequate reuse or recycling options, to properly handle the volume of oil collected and also to address the specific properties of the specific waste in addition to assessing the degree to which used oils could be treated as mentioned the guidelines for the Management and Handling of Used Oil 2000, prepared by the Ministry for the Environment in New Zealand [8].

Recycling, Reuse and Recovery

30. ***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. First

of all, it is important to recycle the hydrocarbon content of the used oils. Re-Refining could be considered as one of the preferred methods for the disposal of used oils; this is because this method has the beneficial effect of reducing the consumption of the virgin oils. It is important to note however, that, the Re-refining method is very sensitive to the scale and the economics of the operation (for example, thousands of tons per year of used oils would require sustaining such a re-refining operation).

A- Reprocessing and Re-refining

31. Generally, reprocessing and re-refining involve operations that would separate and remove contaminants in the used oils to an extent that such used oil becomes suitable for reuse. The contaminants that are removed in this process would eventually be part of the waste streams that must be disposed of in an environmentally sound manner.

32. *Reprocessing*. In this operation, relatively simple physical/chemical treatments operations- such as settling, dehydration, flash evaporation, filtration, coagulation and centrifugation- are applied to remove the basic contaminants that exist in the used oils. The primary objective of reprocessing is to clean the oils to the required extent for use in less demanding applications, i.e.: not to clean the oils to the extent of producing a product that is comparable to virgin oil. It is important to note that, direct Reprocessing is not feasible for mixed oils; accordingly, segregation of the used oil at the source stocks is essential. Finally, reprocessed oils are most commonly used in industrial applications.

33. *Re-refining*. This operation requires modern processes that 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 initially heated in stages then dehydrated and finally distilled under vacuum to separate into various grades of distilled oil. these distilled oils may be subsequently hydro-treated to produce a fine clear product. The by-products that 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 remainders of the by-product materials are residues or waste streams such as acid tar, spent clay, centrifuge sludge and process water that are directed to further treatment operations and/or disposal.

34. It must be noted that Re-refining processes may not be viable on economic grounds in certain cases, due to the high costs of such processes. The regenerated products, such as lubricants, usually sell for somewhat less than premium quality new materials. Consequently, the *regeneration* processes are constrained by the prices of both the feedstock and the product which are generally dictated by the oil prices. Accordingly, if the regeneration activity is to be economically viable the margin between feedstock costs and product income must cover the total *regeneration* process costs. It is important to note that, this process produces wastes that must be disposed of and the disposal costs of the residues could represent a significant proportion of the total costs. *regeneration* processes however, could reduce the amounts of waste that goes to the final disposal,

resulting in significant economic benefits.

35. The three most commonly used re-refining technologies that aim at ensuring optimal yield of product and meet the utility and energy requirements in addition to limiting the hazardous chemicals that are used as well as the volumes of waste produced are the following:
    - Acid/clay Re-refining process
    - Vacuum distillation/clay process
    - Vacuum distillation / Hydro-treating process.

36. The first Acid/clay process has a long operational history, it is not highly sophisticated and is appropriate to a wide range of circumstances; consequently, it is readily adopted in most countries. However, a number of studies made to rank the re-refining by-product waste streams in terms of environmental hazards, indicated that the acid/clay process is the least environmentally sound of the three main re-refining processes mentioned above. The basic reason for this is the large quantity of by-product acid tar that is produced which presents significant difficulties in disposal. Accordingly, it is highly recommended not to use this acid/clay process in case there is no facility or even inadequate capacity or facility to treat and dispose of the acid sludge resulting from this process.

37. The second vacuum distillation involves the distillation of oils under sub-atmospheric pressure thereby lowering the necessary operating temperature and reduces any problems of thermal breakdown. In this process, clays with high adsorptive capacity are used to remove both the impurities -such as heavy metals and the breakdown products- that result from the use of the oil. Actually, clays are frequently used before distillation to provide a cleaner feed as well as a final polish to the recovered oil. The problems of acid tar disposal are quite serious; if there was a more economical and environmentally sound way for treating acid tar, the overall process could then be operated in a more efficient manner. Technical solutions to many of these problems have been developed and are being increasingly applied. Inspite of that aspect, the proper management and rapid commercialization of existing distillation methods to overcome the environmental problems of the disposal of acid tar are quite necessary.

38. The third catalytic hydro-treating method for handling/ utilizing 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 the contaminated organic waste streams is however, 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, although the disposal costs of the organochlorine- contaminated oils could be substantially reduced. Accordingly, the use of this type of catalytic treating technology could result in positive economic benefits.

39. In recent years, the increase in the variety of used oils has resulted in the fact that traditional oil treatment processes, based on acid/earth technologies, do not obtain the required qualities for the resulting base oils. Moreover, concern over

environmental issues makes it even more difficult to obtain suitable processes. The aforementioned technologies that are based on processes using acid and earth are at present obsolete for environmental and economic reasons. From the point of view of the Economics, large investments need to be made in installations while from the point of view of the environment, there is the problem of treating the acid earth generated in the process. Resolving these problems has resorted to the introduction of technologies that incorporate Vacuum Distillation and Hydrogenation processes.

B- Recovery (controlled burning)

40. The next option after reprocessing and re-refining is the recovery of oils that focuses principally upon the use of used oils as fuels. 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 a good practice, unless it can be demonstrated that combustion of the waste can be undertaken in an environmentally sound manner. The Environmental Impact Characteristics for used oil re-use options are given in Table 3. Actually, the use of waste oil as a fuel is possible because any contaminants do not present problems in combustion or problems of burning in an environmentally sound manner, considering such burning does not require modification of the equipment in which it is being burnt. Usually, used oils for use as fuels need to be subjected to treatments involving some form of preliminary settlement, to remove sludge and suspended matter. Simple treatments of this type, can substantially improve the quality of the material, by removing sludge, suspended matter, carbon as well as some degrees of heavy metals [6].

41. Used oil burners is one of the main end users of recycled oils, and they supplement their base gas load or liquid fuel supplies with recycled oils to lower their operating costs. On a heating value parity basis, used oils are discounted compared to virgin liquid fuels or natural gas. This reflects the quality considerations of the fuels in question. These Considerations factors lead to a range of discount of 25–35% from No. 6 fuel oil grade. This discount, range reflects normal market factors, distances from source, and quality considerations. Many burners attempt to maximize used oil combustion up to physical or environmental limits. Actually, such burners compete with re-refiners for access to 'low cost used oils'.

42. Used oils have been traditionally directed also to a variety of uses other than Re-refining and burning; such uses include: as a raw material in asphalt production road oil, flotation and forming oil, secondary lubricant, pesticide carrier, weed killer, livestock oil, all-purpose cleaner, and vehicle undercoating. Under certain conditions, used oils can also be adopted in oil refineries to aid the manufacture of other refined products. Used oils have been applied to gravel roads as a dust suppressant for many years. Such use was most commonly adopted in rural areas, which have a high proportion of unpaved roads and are located some distance away from other markets of used oil where burning and re-refining operations could be carried out.

43. Whilst some ‘road oiling’ is still common in many areas of the world yet, its popularity has declined in recent years, not only because of the reductions in the proportion of unpaved roadways, but also due to other aspects, such as the problems of contaminants in used oils (PCBs). The competition is from other end uses of used oil (re-refining), as well as the availability of alternative dust suppression substitutes (calcium chloride, surfactants), and above all the environmental regulations enforced nowadays. In fact, research studies suggest that the potential impact, generated by road oiling on both the health and the environment, are quite severe to discourage or prohibit such Road oiling practice. In conclusion Road oiling with contaminated oil, results in very serious environmental problems.

44. Used oils have been occasionally used in the manufacture of asphalt as cutting stocks and extenders. Because the constituents of the used oils are essentially insoluble in water, then the potential contaminants are usually coated with viscous asphaltic materials and subsequently incorporated into the final product. It is important to note that, Leaching of significant concentrations of contaminants from finished asphalt roads and roofs is quite unlikely; hence, the potential effects of using waste oils in asphalt production should be evaluated based on the specific site of its use. The hot coating of road stones with asphalt has resulted in environmental problems that lead - in certain circumstances - to the setting for this purpose of a 10 ppm limit for PCB in used oils. Regarding waste management practice, a number of countries are prohibiting the use of such waste oils. Finally, even the Dilution of used oil by blending with virgin fuels must be practiced with caution adopting possible dilution protocols.

45. The environmental effects associated with the other end uses of used oils as listed earlier, vary from one application to another. The nature and extent of concerns for any of those applications depends on the volume of oil used, the operational practices of the companies or individuals involved, and also on the manner in which the oils are ultimately discharged to the environment. In general, these practices should be avoided unless it can be demonstrated that Environmental Risks can be effectively controlled on a site-specific basis.

46. Space heaters are small fuel combustion devices that are used in garages and mining operations during cold weather conditions for heating water. These devices are normally fueled with heating oil or natural gas but can also be designed to burn used oils in order to save on heating costs. Also, considering the economic impact on small garages and mining operations and the opportunity to avoid improper disposal of used oils, then used oil generators may utilize space heaters to burn their used oil.

47. Although some of the reuse and recycling alternatives for used oils are technically sound yet, the costs involved in both the re-refining process and the Combustion of used oils can be very high. Accordingly if a strategy for hazardous waste management is considered then source reduction should be a primary objective. From the economics point of view, it is obvious that the reuse and recycling operations of used oils must be initially examined as a preferred option before considering the final disposal of the used oil. It is important to note that, in certain

circumstances re-refining may not provide an adequate Return on Investment (ROI); in such cases viable and ecologically sound alternatives should, be investigated before considering final disposal options. Furthermore, the direct burning of used oils in conventional combustion devices can also create serious pollution problems and, although fitting pollution abatement equipment can reduce such handicap yet, in most cases, this is not very practical. Whilst the burning of used oils in specially designed ‘Waste Incinerators’ can reduce such pollution problems yet, such, process is very expensive, especially if provision for energy recovery is not included.

48. The used oil collection system can be divided as follows:

- Small volume generators
- Public collection points
- Industrial/commercial sites
- Transportation and collection agents
- Used oil transfer facilities and/or tank farms
- Processors
- End users such as cement kilns or disposal services [8]

The effective collection and transport of used oils from the point of their generation to recycling or end-use locations is essential, if used oil is to be utilized or disposed of in an environmentally acceptable and safe way as illustrated in Figure (1).

Classification of Public Collection Sites

49. Public collection point sites for used oils are classified as either 'Controlled Collection' or 'General Collection' sites; such points are based on the site manager’s ability to prove that the used oil on site is not contaminated by other products. All Collection sites must have a 'Dangerous Goods' license, issued by the appropriate ministry. Classification of Public Sites is carried out on the basis of the following criteria:

1-Controlled collection sites:

A used oil public collection point can be classified as a controlled collection site when the local Dangerous Goods Inspector is satisfied of the following aspects:

a-The site can demonstrate, by appropriate in-house procedures for handling used oil, that it is protected from receiving unwanted or contaminated oils.

b-The used oil at the site is stored in a container that complies with the minimum design specifications.

2- General collection sites:

a- A used oil public collection point that cannot show that it is protected from receiving unwanted or contaminated oils will be classified as a general collection site.

b- Storage equipment at these collection sites must comply with the Regulations related to the Dangerous Goods (Class 3 – Flammable Liquids).

50. In November 1986, the US Environmental Protection Agency (EPA) issued a decision, not to list recycled used oil as a hazardous waste material (51 FR 41900). The agency reached its decision after determining that used oil after being recycled should not be listed as a hazardous waste under the Resource Conservation and Recovery Act (RCRA).

Some steps are usually taken to improve collection and increase re-refining and other beneficial re-use of used oils. The key steps taken are generally related to achieving two key objectives: The first step is to increase the effectiveness of used oil recovery programs with the aim of minimizing the potential for disposal of used oils into landfills or other improper outlets.

The second step is to increase the volume of the used oil that could be available for re-refining since this process offers the maximum energy conservation and environmental benefits.

51. Nowadays it appears that, consumers are becoming more environmentally conscious and are increasingly more reluctant to dispose of used motor oil in a non-environmentally friendly way, accordingly, the magnitude of the environmental issue is lessened. Nevertheless, inspite of such a positive aspect yet, special attention is necessary when in dealing with the very cost conscious consumer segment that may not be aware of the serious environmental consequences of improper disposal of used oils.

52. The acceptance of re-refined oils in the market is nowadays improving. Actually, when re-refined oils were first used in motor oils, the industry enforced the adoption of warning labels to indicate that the product (Motor Oil) contained recycled oils. Such warning practice no longer takes place and re-refined oils can be used in motor oils as long as they meet the industry certification requirements.

53. Recently, the activities of the European Commission as related to the management used oils indicate that such subject continues to be a controversial issue with many varied opinions. Recently, environmental restrictions on the combustion of used oils are becoming more restrictive.

54. As a matter of fact, in 2005 more stringent controls were placed on the combustion of used oils due to the continuing concerns over air pollution impacts. As a result, there is actually grave concern nowadays that such stringent control could reduce the collection rates and increase the discarding of used oils [6].

55. Similarly, it important to note that under "Europe’s Waste Incineration Directive” the “Rules on Burning Waste Oil as a Fuel" changed in December 28, 2005 in order to tighten the controls on the resulting emissions from the burning process. waste producers are being warned that it is “unlikely” those current users of waste oil can meet these new standards and consequently, the market for waste oil will therefore shift radically. New outlets for the waste oil material are likely to include the steel industry and cement kiln burning and will even limit the combustion of used oils in road stone asphalt coating plants. The use and handling of waste oils are discussed hereunder.

III. Waste Oil

56. The various operations of the Oil & Gas Industry generate oily wastes as by-products that are mainly composed of earth solids with oily liquid retained on the solid particles. These wastes from drilling operations, produced water, slops and sludge resulting from crude oil refinery & transport vessels, refinery emulsions, separator sludge, in addition to tank bottom sediments and ships slops.

57. Petroleum inputs into marine waters worldwide are manifested through these four major sources:

1. Natural seeps and anthropogenic releases that occur during the extraction, transportation, and consumption of petroleum.
2. The Heavy Hydrocarbon Fractions accumulate as bottom muck kill plant and bottom animal life when released to the surface waters.
3- The dissolved or emulsified Fractions act as toxic agents depleting the oxygen content of water bodies.
4- Floating Fractions create fire hazards, and coat banks and boat hulls. Such fractions also contaminate the water, interfering with fishing and recreation.

Sources of Waste Oil

58.A major source of *oily wastes* that arise worldwide, is the sludge recovered from tanks used for the storage of leaded Gasoline (petrol). Tank Sediments are emulsions that are formed from the solid particles, heavy oil and water that settle to the bottom of the tanks over the passage of time. Those tanks are periodically emptied and the sediments removed. The tank sediments are identical to the hazardous constituents potentially present in crude oils; they include benzene, toluene, ethyl benzene in addition to xylenes, sulfur, poly-nuclear aromatic hydrocarbon (PAHs) and metals.

59.*Oily waste* can kill fish, marine mammals, birds and their offspring, and can also destroy plant life. Even small spills in certain areas can damage the ecological balance and cause long-term harm to both the environment and aquatic life. It is difficult to determine exactly how much damage is caused by illegal dumping, partly because it is unknown how much oily waste is being dumped.

Source Reduction Practices

60. Commercially valuable oil is recovered from refinery-products. The USEPA Resource Conservation and Recovery Act classified the hazardous waste oil sludge by a series of volatilizing and condensing steps that vary depending on the oil, water, and solids content of the sludge. Such steps result in the production of non hazardous water and solid waste byproducts.

61. Any oil sludge treatment system separates and recovers oil from the oil sludge. The technology involved incorporates various processes including a centrifuge, a purification systems and stabilization. Once separated and purified the client can reuse the recovered oil. The remaining solid can be disposed of in secure landfill or destroyed thermally. The waste water can also be treated at site to meet the discharge standards.

62.A low viscosity, high oil- and/or water-content sludge is first centrifuged to separate the free oil and water. On the other hand, the thick waste oil sludge, the centrifuge solids, or the other sludge that are low in oil and/or water content are heated to evaporate the water and oil contained. The dry, friable, de-oiled solids are then recycled with the oily sludge feed to prevent material agglomeration and heat exchanger fouling. The oil and water vapor however, resulting from the high-temperature volatilization evaporator apparatus is recycled as an indirect heat source to the low-temperature volatilization apparatus. The oil and water are essentially separated as by gravity in a settler. The separated oil is centrifuged once again to remove any entrained water and solids. Subsequently, the 'nearly' oil free, non hazardous waste water and non hazardous, de-oiled solids can be disposed of in a conventional manner, and eventually the commercially valuable recovered oil is suitable for further refinery use.

63. The oil sludge, which is normally produced by high-pressure 'water jet cleaning' of storage tanks, consist of iron oxide corrosion products and sediments, onto which organic and inorganic lead compounds have been adsorbed and mixed with the fuel. The 'Free Fuel' is usually removed readily by either gravity or by mechanical separation, and used as an energy source. The highly toxic organic lead compounds that are associated with the sludge have to be chemically or thermally oxidized to inorganic lead compounds to facilitate their disposal.

64. Active bacteria are sometimes utilized in natural biological systems. Actually, bio-remediation technology is able to treat various types of waste matrices such as oily sludge, tars and contaminated soil. The bio-remediation technology can also be used to treat groundwater that has been contaminated with phenols, poly aromatic hydrocarbons, organic solvents and other volatile hydrocarbons.

65. Since 1991, a large number of facilities use a preliminary treatment method prior to removing the sediments. This treatment usually consisted of washing the tank with hydrocarbons. The liquid captures the organic compounds in the sediments; subsequently the liquid is recycled to the crude unit via the recovered oil system.

66. Many petroleum facilities use permanent mixers in their crude tanks to deliver homogenous feed to the crude unit. Those mixers also serve the function of entraining the particulates and the heavy hydrocarbon that would eventually result as Tank Sediments, into the crude unit feed.

67. In the case of a crude oil spill, the primary concern is with the heavy hydrocarbon emulsions. These emulsions include asphaltenes, paraffins and tar. Usually, the higher the temperature of the oily waste, the easier it is to separate the oil from the water.

68. A strong de-emulsifier is usually added to the oily sludge emulsions that result from many industries, including oil re-refining, collection points for waste oil disposable, petrochemical plants, crude oil storage facilities, process operations, tank cleaning services, and oil spills at sea. The addition of such strong de-emulsifier will promote the reclamation of saleable oil while preventing water pollution. Such means of recovery make possible the reuse of valuable oil for reprocessing, reformulating, or the recovery of energy through burning.

69. It is extremely difficult to dissolve waste oil sludge once it has formed, unless excessive quantities of solvent are used. Solvent treatment cannot be accomplished with ordinary solvent-type chemicals. Actually, this treatment operation must involve sufficient quantities of the proper surface active agents to provide all the benefits.

70. Some of these surface active materials must not only disperse the sludge, but must also be of a definite and specific nature to emulsify the water. The Emulsification of water means the breaking of the surface tensions of both the oil and water, so as to obtain a stable mixture of minute water droplets in the oil globules. The water present in this form will in no way hinder the operation, nor will it hinder the combustion of the oil. Surface-active agents must also be present to act on the surface tension of the fuel thereby improving Atomization and Combustion of the fuel.

Other Uses

71. Cargo and container ships have to follow definite procedures when disposing of the waste oil, solvents, and lubricants that collect in due time in the engine room of a ship. Normally, the water and oil are separated and the oil is stored in a tank as sludge. Some ships burn this sludge in incinerators that are available on the ship. Others store this sludge until the ship reaches port, where it can be properly disposed of.

72. Thermal destruction technology employed in modern cement kilns for complete incineration and treatment of the waste is generally preferred as compared to processes that generate organic hazardous wastes. The high temperature (1,200 – 1,400 $^{\circ}$C) and the long retention time inside a Cement Kiln ensure that the mixture is completely destroyed. This thermal destruction technology enables the recovery of the calorific value and/or the useful materials contained in the wastes through converting them into Alternative Fuel and Raw Material (AFR).

73. Generally, all tanks eventually accumulate sludge, but the worst problems occur in crude tanks at the Production locations. In small production sites, the beneficial aspect requires that the sludge material be reused without treatment. The amendment of asphalt road base material, using tank bottom sludge - to create an "asphalt-like" material- should prove very economical for use in road base mixtures employed in 'light-duty' roads.

Environmental Impacts

74. A large range of used (waste) oils can be recycled and recovered, either directly in the case of wastes with high oil content, or after some form of separation and concentration in the case of materials from high aqueous content.

75. Disposing of the sludge in the proper manner can be expensive and time consuming. Instead of following complex procedures, 'Disreputable Engineers' install hoses to bypass pollution-control systems and simply pump the waste overboard.

76. Natural oil seeps, occurring when crude oil seeps into water from geologic strata beneath the sea floor, are often used to identify the potential economic reserves of petroleum. These crude seeps contribute the highest amount of petroleum to the marine environment, accounting for 45% of the total annual load to the world's oceans. Improved Production Technology and safety training have however, dramatically reduced both blowouts and daily operational spills during the past decade.

77. Releases resulting from petroleum transport amount to less than 13% of petroleum inputs worldwide. The major sources of transportation-related spills include pipeline spills, tank vessel spills, operational discharges from cargo washings and coastal facilities spills. Transportation-related spills have actually decreased by increasing the regulation, phasing out the older vessels, and introducing new technology and safety precautions.

IV. Used Vegetable Oil

78. Used Vegetable Oils are oils that have been used as raw material for cooking processes in restaurants, large canteen facilities, fried food establishments, catering, food industries, etc [9]. The disposal of used vegetable oils is one of the main environmental problems. Actually, uncontrolled disposal seriously damages the sewage system, blocks the pipes and causes unbalance to the aquatic ecosystem.

Origin of Vegetable Oil

79. Vegetable fats and oils are found in abundance in fruits and seeds. Vegetable oils are esters of glycerol with different higher fatty acids. A fatty acid is a long hydrocarbon chain with a carboxyl group at one end. Most animal and vegetable fats and oils contain fatty acids with 14 to 22 carbon atoms in their hydrocarbon chain. Edible fats and oils are primarily composed of triglycerides. Since there are numerous and different fatty acids that occur in natural fats, many different triglycerides are thus encountered in nature. These compounds are named according to the fatty acid or acids they contain. Fats and oils are always practically composed of mixtures of triglycerides in varying proportions. Apparently, no natural fat or oil consists solely of a single triglyceride. The properties of different fats and oils depend upon the characteristics of the triglycerides from which they are formed and also upon the proportions of these triglycerides to one another.

80. The common physical properties of such oils and fats are that they float on water but are not soluble in it; in addition that they are greasy to the touch, and have lubricating properties. They are also not readily volatile; and may be burned without leaving any residue. Table (4) gives the characteristics of the oils and esters.

Waste Vegetable Oils

81. Every year many millions of tons of waste cooking oils are collected and used in a variety of ways throughout the world. This is virtually inexhaustible source of energy that might also prove an additional line of production for 'green' companies. These waste cooking oils contain some degradation products of vegetable oils and foreign material. The analyses of used vegetable oils however, indicate that the differences between the used and the unused fats are not very great, and in most cases just simple heating and removal of solid particles by filtration of suffices for subsequent trans-esterification. The Cetane Number of a used frying oil methyl ester was given as 49, thereby comparing well with other materials. Complex physical and chemical changes occur during 'deep-fat frying' leading to thermal and oxidative decomposition.

82. The break down of oil is mainly caused by hydrolysis, oxidation and polymerization reactions that take place at high frying temperatures in the presence of oxygen and also moisture that lead to physical and chemical changes in the oil itself. Actually, the physical changes are mainly increased viscosity and foaming, color changes and decreased smoke point. On the other hand, the main chemical changes have increased 'Free Fatty Acids' FFA, polar components and high molecular weight products as well as decreased levels of saturation, flavor quality and nutritive value. The frying temperature heat is a process factor that affects the rate of oil degradation and accelerates the formation of FFA as well as the polymerization reaction.

The formation of volatile and non-volatile products during oil decomposition affects the functional and nutritional properties of the oil and consequently also of the food that is being fried. The volatile degradation products are mainly responsible for flavor in both the oil and fried food.

83. The major chemical decomposition of the oil during frying is hydrolysis. In the oxidation reactions however, the oxygen in the air, resulting in the break down of the hydrocarbon chain, oxidizes the carbon atoms next to the double bonds in the triglyceride structure. This leads to the formation of volatile compounds, such as short chain fatty acids, hydroperoxides, aldehydes, ketones, alcohols, and other compounds that contribute to off-flavors in the oil. Hydroperoxides are unstable at high frying temperatures and thus decompose immediately to secondary oxidation products (alcohols, aldehydes and ketones).

84. Oils with higher degrees of un-saturation are more reactive with oxygen and therefore, more unstable during the frying process. Trace metals such as copper and iron, speed up the oxidation reactions particularly at high frying temperatures by catalyzing the decomposition of hydroperoxides into secondary oxidation peroxides. These metals should never be used in the frying equipment. A third type of oil degradation process that takes place during frying is the formation of cyclic monomers, dimers and polymers through polymerization. This type of reaction, will lead to changes in physical properties of the frying oil such as color, viscosity, density and solidification characteristics.

85. The lack of specific legislation on oils used for food purposes, in addition to the fact that the population in general produces used vegetable oils, means that most of these oils end up in the sewage system, which causes problems in the purification of the urban wastewater.

86. The mixture of oil and water forms in the sewage system an impermeable film that prevents oxygen from entering thus causing the death by asphyxia of the micro-organisms that purify the wastewaters. Consequently, the efficiency of the treatment installations is reduced because more time and much more energy are needed to break down these oil slicks.

87. The most common soaps are the fatty-acid salts of sodium (sodium is a soft, white metal obtained from common salt, sodium chloride) and potassium base. Potassium is also a soft, white metal obtained from wood ashes or from certain minerals.

Collection Logistics

88. The collection logistics of used vegetable oils is conditioned by the entities that generate them; this is because the largest quantity of used vegetable oil is produced in the commercial and traditional restaurant industry, hotels, fast-food chains and industrial kitchens. Community restaurants however, produce less used vegetable oils due to the fact that the meals in some of them (hospitals, rest homes, etc.) are more restrictive in view of the people who normally stay in these centers. Obviously, used vegetable oils that result from domestic use are smaller in quantity than those originating from large commercial restaurants; in addition, the quality of the used oils varies according to the type of centre that they originate**.**

89. The collection process is divided into two stages:
The first stage is the collection and storage by the centers that have used the vegetable oils in their activity. The second stage is the Collection and Transportation of the oils to the companies in charge of treating them. Whilst Regulations do exist in some countries that compel restaurants to renew vegetable oils that have been used yet, in general it can be stated that there are No Regulations regarding the management of these used vegetable oils, although some initiatives are beginning to appear in this respect.

90. As a general rule, used vegetable oils are stored in metal or plastic containers with a lid, to prevent contamination by other particles or compounds.

91. One of the factors that are of vital importance in the collection process of such oils is the separation of those used vegetable oils, because this separation contributes to making the tasks of recycling easier and, at the same time, the products that are obtained are of a higher quality. Government authorities must recognize companies that specialize in collection.

Treatment of Used Vegetable Oil

92. The preliminary treatment process of used vegetable oils involves their recovery through collection from the establishments where they are generated and then transportation to the treatment centers.

93. About 60 % of the oils obtained in the recycling process are used in the production of feedstuff. This percentage represents the highest quality oils that are recovered.

94. The remaining 40 % is used in other industrial processes, such as the production of biofuels, surfactants, paints, etc. This percentage represents the lower quality oils that are recovered. The treatment process consists basically of: *filtration*, followed by a hot water treatment to finally clarify the oil that is being treated.

95. *Decantation and filtration*: the oils and fats that are collected are initially separated from the water and other impurities, then they are pumped out and they undergo a second filtration process, followed by decantation again. In each decantation step, the oils separate out and become purer in each time. *Purification*: The dirtiest oil of all is circulated through a reactor that operates at a specific temperature is also subjected to continuous agitation at the same time. This agitation causes any water that is mixed with the oil to evaporate and is subsequently eliminated through a condenser.

Possibilities of Using Recycled Vegetable Oils

96. Transesterification of vegetable oil was conducted as early as 1853 many years before the first Diesel Engine became functional. Biodiesel Fuel can be made from new or used vegetable oils and animal fats. It is a renewable source of fuel and is based on the oil crops that are grown anew each year.

97. Biodiesel was demonstrated to have significant environmental benefits in terms of reduced emissions and decreased global warming effects. Pure Biodiesel is biodegradable, nontoxic and essentially free of sulfur and aromatics.

98. Biodiesel offers a cleaner alternative to petroleum diesel fuel. It requires the use of the same Diesel Engine with no engine modifications or changes in the fuel handling and delivery systems.

99. Used vegetable oils are also used in the manufacture of industrial lubricants mainly in steel mills.

100. Used vegetable oils when subjected to the aforementioned preliminary treatment can be used in the production of animal feedstuff.

101. Used vegetable oils are also used in the manufacture of surfactants i.e. for the production of soaps and detergents.

102. Used vegetable oils are utilized as a fuel by direct or mixed combustion thereby providing a high calorific value of 8,500 kcal /kg.

Elements to be Considered for Environmentally Sound Management

103. Although some of the reuse and recycling alternatives for used oils are technically sound, the costs involved in both the re-refining process and combustion of used oils can be very high. In this regard, and for developing a strategy for hazardous waste management, source reduction should be a primary objective. From the economic point of view, it is obvious that the reuse and the recycling operations of used oils must be examined initially as a preferred option before considering the final disposal of the used oil. In certain circumstances re-refining, may not provide an adequate return on investment; in such cases viable and ecologically sound alternatives should, be investigated before considering 'final disposal options'. The direct burning of used oils in conventional combustion devices can also create serious pollution problems and, although fitting pollution abatement equipment can reduce such handicap yet, in most cases, this is not very practicable. Although the burning of used oils in specially designed ‘waste incinerators’ can reduce these pollution problems yet, on the other hand, such process is very expensive, especially if provision for energy recovery is not included.

104. 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; such criteria are outlined as follows and include the extent to which used oil can be treated to obtain specific products. This criteria include:

- The potential harm to human health and to the environment.
- The economic balance and market opportunities.
- The transport requirements and transport costs.
- The location of the treatment facility.
- The processing of the hazardous waste contaminants and by products of the specific process itself and the safety of the workers

105. 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 (i.e. the competitive uses of the products). Any process used to select a ‘preferred recycling or reuse option must take into account the fact that the decision should be dealt with by only experienced professionals and waste managers. This is because a critical assessment must be made of a number of factors before arriving at a final decision. The contaminants and associated environmental/health risks will eventually limit the number of acceptable reuse or recycling options of used oils. also, the availability of waste management resources (collection, storage, transport and treatment) will equally restrict the selection of environmentally sound disposal options (that include blending, segregation, gravity separation, strategic storage for the preparation of optimal feed stock blend, etc.). Finally, the economic viability, the social acceptability as well as the regulations would form part of the analytical procedure. Needless to mention the ‘economic viability’ is affected by: transport costs; end uses; pollution abatement investment; etc.), social acceptability considerations as well as Regulations would form part of the analytical procedure.

106. In conclusion, the 'basic criteria' for the 'selection process' of environmentally sound reuse or recycling options of used oils should be based, on the following considerations:

- Feedstock quality (upstream): degree and nature of contamination and environmental/health risks associated with handling and processing, in addition to volumes and types.
- Treatment processes for obtaining appropriate quality feedstock for downstream industries or users, impacts on resource conservation, as well as the percentage of the product recovered, and the 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.
- Economic considerations including economic viability, market sustainability and commercial feasibility in addition to product value.
- Technology and techniques involving and treatment capacity, feedstock capability in addition to 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 on air emissions………etc.
- Socio-economic benefits employment opportunities……etc.
- Availability of cleaner production methods and clean technologies.
- Knowledge of past cases or processes that have gone wrong.

107. 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', the standards for the environmentally sound management of the recovery operation in both the export and import sectors should be considered. As a matter of fact, it is important to emphasize that, 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 as well as decommissioning.

108. Further consideration to the above 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. Finally, a number of elements should also form part of the 'Decision-Making Process', typical of those elements are the following:

- 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 involved.

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Appendix

Table 1: Listing of Common Additives in Used Oils

Additive	Usage
Zinc dithiophosphates, acid phosphates, organic sulfur and chlorine compounds. Sulphurized fats, sulfides and disulfides	Antiwear
Metallo-organic compounds of sodium, Calcium and magnesium phenolates. Phosphonates and sulphonates	Detergent
Zinc dithiophosphates, metal phenolates, fatty acids and amines	Anticorrosion
Alkylsuccinimides, alkylsuccinic esters	Dispersant
Organic fatty acids. Lard oil. Phosphorous based compounds	Friction Modifier
Alkylated naphthalene and phenolic polymers, polymethacrylates	Pour point depressant
Organic phosphates aromatic hydrocarbons	Seal Swell Agent
Polymers of olefins, methacrylates, di-enes or alkylated styrenes	Viscosity Modifier
Silicone polymers, organic copolymers	Antifoamant
Zinc dithiophosphates, hindered phenols. Aromatic amines, sulphurized phenols	Antioxidant
Organic complexes containing nitrogen and sulfur amines, sulphides and phosphates	Metal Deactivator

Table (2): Comparison of Virgin and Waste Lubricating Oil Properties (Gergel, 1992)

Properties	Virgin Lube Oil	Used Lube Oil
<u>**Physical Properties**</u> Specific gravity	0.882	0.910
Dynamic viscosity SUS @ 100 F	-	324.0
Bottom sediment and water volume %	0	12.3
Carbon residue, wt%	0.82	3.00
Ash content, wt %	0.94	1.3
Flash point, F	-	348
Pour point, F	- 35	-35
<u>**Chemical Properties**</u> Saponification number	3.94	12.7
Total acid number	2.2	4.4
Total base number	4.7	1.7
Nitrogen, wt %	0.05	0.08
Sulfur, % wt	0.32	0.42
Lead, ppm	0	7.535
Calcium, ppm	1.210	4.468
Zinc, ppm	1.664	1.097
Phosphorous, ppm	1.397	931
Magnesium, ppm	675	309
Barium, ppm	37	297
Iron, ppm	3	205
Sodium, ppm	4	118
Potassium, ppm	< 1	31
Copper, ppm	0	29

* *Average Properties for 300 used oil sample*

Table 3: Re-use Options of Used Oil Environmental Impact Characteristics

Item	Burn in Space Heaters	Industrial Burning	Re-refine
Lead	50+% to air, balance to ash deposits	50%+ to air (90+% less with pollution control equipment) balance to ash	100% to asphalt
Cadmium	50+% to air; balance to ash	50%+ to air (90+% less with pollution control equipment) balance to ash	100% to asphalt
Chromium	<50% to air balance to ash	50%+ to air (90+% less with pollution control equipment) balance to ash	100% to asphalt
Zinc	50% to air, balance to ash	50%+ to air (30+% less with pollution control equipment) balance to ash	100% to asphalt
Sulfur	SO_x to air	SO_x to air, possibly scrubbed to form neutral salt	Burned to SO_x scrubbed with caustic to form neutral salt
Nitrogen	NO_x to air	NO_x to air	NO_x to air or pollution control equipment
Polynuclear hydrocarbon	CO_x to air, ash /soot	CO_x to air, ash/soot	Removed by hydrotreatment
Chlorinated hydrocarbons	HCl to air minimized in feeds	HCl to air, possibly scrubbed to form neutral salt	HCl scrubbed with caustic for form neutral salt
Phenols	COx to air	COx to air, fraction to wastewater	To fuel by-product or to wastewater treatment
Waste streams	Ash deposits	Wastewater, filtration solids, oily sludges, tank bottoms, ash	Wastewater, tank bottoms, ash

Table (4): Characteristics of Oils and Esters

Type of Oil	Melting Range ˚C			Iodine number	Cetane number
	Oil / Fat	Methyl Ester	Ethyl Ester		
Rapeseed oil, h. eruc.	5	0	-2	97 to 105	55
Rapeseed oil, i. eruc.	-5	-10	-12	110 to 115	58
Sunflower oil	-18	-12	-14	125 to 135	52
Olive oil	-12	-6	-8	77 to 94	60
Soybean oil	-12	-10	-12	125 to 140	53
Cotton seed oil	0	-5	-8	100 to 115	55
Corn oil	-5	-10	-12	115 to 124	53
Coconut oil	20 to 24	-9	-6	8 to 10	70
Palm kernel oil	20 to 26	-8	-8	12 to 18	70
Palm oil	30 to 38	14	10	44 to 58	65
Palm oleine	20 to 25	5	3	85 to 95	65
Palm stearine	35 to 40	21	18	20 to 45	85
Tallow	35 to 40	16	12	50 to 60	75
Lard	32 to 36	14	10	60 to 70	65

REGULATIONS FOR HANDLING OF USED OILS (IARC 1984)

CPSC: Products containing 10% or more of petroleum distillates require Special labeling due to aspiration hazard Special packaging is required For any household products, drugs, or cosmetics containing 10% or more of Hydrocarbons and with a viscosity less than 100 Seconds Saybolt Universal (SSU)

EPA: Federal Insecticide, Fungicide, and Rodenticide Act Tolerance for Mineral Oil residues on corn, grain, and sorghum = ***200 ppm***

FDA: Drugs for pasture cattle may contain up to ***1%*** mineral oil over the counter products containing mineral oil must contain a warning label.

OSHA: Permissible Exposure Limit (PEL) equals ***5 mg/m^3*** Mineral Oil mist.

Guidelines

ACGIH

Threshold Limit Value - Short Term Exposure Limit (TLV-STEL) = ***10 mg/m^3***

Threshold Limit Value - Time-Weighted Average Limit (TLV-TWA) = ***5 mg/m^3*** (mineral oil mist)

NIOSH

Immediately Dangerous to Life and Health (IDLH) = ***2,500 mg/m^3*** (mineral oil mist)

Short-Term Exposure Limit (STEL) = ***10 mg/m^3*** (mineral oil mist)

Recommended Exposure Limit (REL) = ***5 mg/m^3*** (mineral oil mist)

Fig (1): THE FLOW OF USED OIL THROUGH A COLLECTION SYSTEM