Trends in Used Oil Composition and Management

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ABSTRACT

In 1983 Franklin Associates, Ltd. prepared a major technical report for the U.S. EPA's Office of Solid Waste. This report developed baseline data on the composition and management of used oil generated in the United States.

Traditionally, a significant fraction of the used lubricating oils generated in the United States have been environmentally mismanaged. Contaminated used oils with little or no processing commonly have been used for dust suppression or burned in boilers without pollution controls. As a result, the hazardous contaminants present in the oil have been dispersed into the environment, and health impacts may have occurred.

The U.S. EPA has attempted to minimize the health risks associated with improper used oil management by promulgating regulations under the authority of RCRA and the Used Oil Recycling Act. While the U.S. EPA has been developing and proposing regulations for used oil, the quality of oil has been improving due to the decrease in the lead content of gasoline. This paper examines the changes occurring and expected to occur in used oil composition and management practices resulting from U.S. EPA regulations and changes in lead levels in gasoline.

INTRODUCTION

Over the past decade, there has been widespread and growing interest in used oil issues. Used oil management practices of the late 1960s and early 1970s were criticized as being wasteful of a valuable resource and harmful to the environment. In general, the concerned parties, which included industry, government agencies and environmentalists, contended that used oils could be handled wisely or unwisely. Wise handling included reuse practices such as re-refining and carefully controlled burning with energy recovery. Unwise handling included such wasteful practices as dumping and even land disposal. Oiling roads with used oil to suppress dust was considered more desirable than dumping or land disposal, but less desirable than re-refining or burning as a fuel.

Studies completed in the early 1970s showed that more than 50% of the generated used oil in the United States was being managed in what were generally considered to be undesirable ways. Less than 10% was refined into new lubricating oil. A larger fraction was burned as fuel, but often without the necessary monitoring to assure that the public was not being exposed to any potentially hazardous substances. Over the next decade, additional studies indicated that most unwise management practices continued to occur at significant levels.

The U.S. EPA has attempted to minimize the health risks associated with improper used oil management by promulgating regulations under the authority of RCRA and the Used Oil Recycling Act. Final rules governing burning were issued on Nov. 29, 1985. On the same day, the U.S. EPA proposed an overall regulatory program that covers all aspects of used oil management. The regulations provide generators, collectors, transporters, processors and end-users with requirements related to storage, testing with a specification, recordkeeping and other administrative requirements.

While the U.S. EPA was developing and proposing legislation, used oil quality was improving; it will continue to improve in 1986. This change in waste oil quality is due not only to a decrease in the lead content of gasoline, but also to behavioral changes in anticipation of the new regulations. Since lead is one of the major contaminants in used oil and since most lead comes from gasoline, this change will influence used oil quality significantly in the future.

This paper presents data on baseline used oil contamination levels and used oil flows as developed for a 1983 Franklin Associates, Ltd. (FAL) study for the U.S. EPA Office of Solid Waste.[1] The 1985 regulations are then briefly summarized followed by a discussion of the changes in oil composition and flows that are expected to result from the new regulations.

BASELINE CONDITIONS

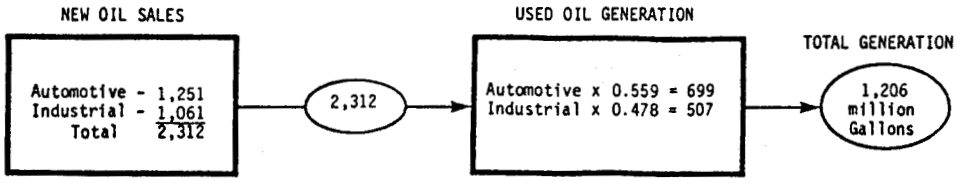
Two data bases were developed as part of the 1983 FAL study for the U.S. EPA: one data base characterized used oil flows through the management system and the other data base characterized contaminant levels in used oil. The flow characterization was accomplished by a literature search, hundreds of telephone interviews and 25 site visits to facilities involved in commercial used oil management.

Much of the information regarding the flow of used oil is undocumented because of the unstructured nature of the used oil management system. Federal regulations prior to 1985 did not require participants in the used oil industry to report their collection procedures or reuse practices.

The used oil composition characterization is based on a series of fairly simple statistical parameters that characterize over 1,000 used oil samples. The concentrations of 19 potentially hazardous constituents were determined, including several heavy metals, chlorinated solvents, aromatic solvents, polynuclear aromatics, PCBs and total chlorine.

Used Oil Generation

In 1983 approximately 1.2 billion gallons of used oil were generated in the United States. The 1.2 billion gallons were generated from the sale of over 2.3 billion gallons of new oil. A summary of the automotive and industrial used oil sales and used oil generation is shown in Figure 1. Approximately 54% of automotive oils enter the used oil market compared to about 48%



Note: All values in million gallons.

Figure 1
Used Oil Generation in the United States in 1983

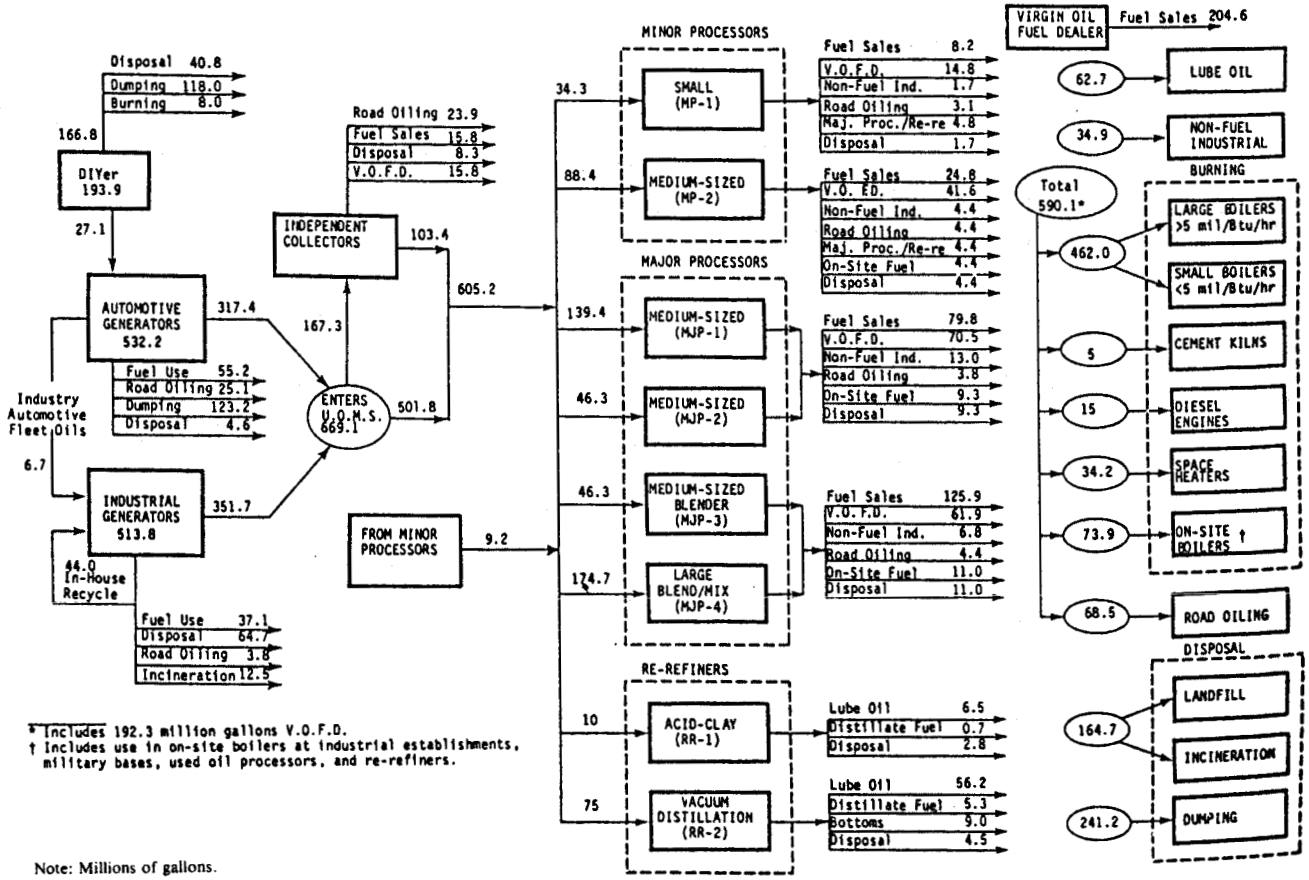
of industrial oils. Generation rates for various used oils take into account losses due to leakage, spillage, combustion, disposal with equipment and incorporation into finished products such as paint, putties, etc.

Used Oil Management System

The used oil management system (UOMS) is comprised of companies that collect, process and sell used oil into several markets. There are three basic types of companies involved in the industry: (1) independent collectors, who only collect and sell the oil; (2) minor and major processors, who collect, process and sell an improved product oil; and (3) re-refiners, who collect, process and sell a refined lube base stock. Many variations exist for each basic type of company.

Figure 2 shows the flow of used oil from the point of generation through the management system to reuse or disposal for 1983. Also included is a description of the reuse practices for generated oil that does not flow through the system. This oil is reused or disposed of directly by the generators. Only 55% (669.1 million gallons) of all generated used oil entered the used oil management system. The remainder was reused, dumped or disposed of by the generators (e.g., those who change their own automobile oil).

The total number of companies involved in the used oil management system in 1983 (excluding 500 to 1,000 independent collectors) was 253. There were only 13 companies involved in re-refining used oil; however, approximately 15% of the oil that entered the management system was re-refined. There were approximately 115 minor processors and 125 major processors.



Note: Millions of gallons.

Figure 2
Used Oil Flow Description in the United States in 1983

The fuel oil market clearly dominated with respect to end-use applications. About 590 million gallons of used oil (nearly 50% of all used oil entering the used oil management system) was burned as fuel in 1983. Approximately one-half of the burned oil was blended with virgin fuel oil before being burned. The industrial market was and is the largest for burning; however, significant quantities also were burned in commercial, residential and institutional boilers.

Comparable quantities of used oil were re-refined and applied to roads for dust control in 1983. Approximately 83 million gallons were received by re-refiners and nearly 74 million gallons were used for roal oiling. Approximately 70% of the oil received by re-refiners became new lube stock, and the remainder was recovered as lighter distillates or was lost during processing.

Approximately 35 million gallons of used oil were marketed for industrial purposes other than fuel. The major application in this category included flotation oils, asphalt extenders and form oils.

In 1983 over 400 million gallons of used oil, out of the total of 1.2 billion gallons generated, were disposed of by landfilling, incineration and dumping. Nearly 50% more oil was dumped than was disposed by landfilling and incineration combined. Most of the dumped oil is automotive oil generated by do-it-yourselfers and large off-road equipment operators such as farmers, moving companies, construction companies and the military.

Used Oil Composition

Analytical data that quantify waste oil contamination in 1,071 samples were obtained from 50 sources for the baseline study. The majority of the results were obtained from state and federal government agencies in unpublished form. Because of the variety of data sources, there is considerable variation in: (1) the constituents that were measured; (2) the precision of the tests; and (3) the detection limits of the equipment. These differences in technique complicate any procedure used to combine the data into summarized statistics.

Table 1 summarizes used oil contamination with respect to 19 specific constituents, 17 of which are included on the U.S. EPA's published list of hazardous constituents. The results are summarized according to percent detection (mean, median, 75th and 90th percentile concentrations), and range of measured concentrations.

The data in Table 1 indicate high levels of contamination for many constituents including lead, chromium, cadmium and several chlorinated solvents. The mean concentrations are badly distorted by a few very high values. The mean concentration for each contaminant is much higher than the median. PCBs were detected in approximately 18% of the samples analyzed.

The data in Table 1 have been categorized according to source and end use with the following generalizations:

- Automotive used oils tend to have higher concentrations of potentially hazardous heavy metals; industrial oils tend to have higher levels of chlorinated solvents and PCBs. No significant differences were noted in the concentration of aromatic solvents or polynuclear aromatics.
- Used oils from gasoline engines have much higher lead concentrations than those from diesel engines due to the presence of leads in some gasoline additives.
- Metalworking industrial oils have higher levels of heavy metals and chlorinated solvents than other industrial oils including hydraulic, compressor, turbine, electrical and others.
- Approximately 30% of the oil samples had a measured flash point below 140 °F,* which is a criterion for classifying a waste as hazardous. Since the flash point for virgin fuel oils is above 350 °F, contamination with low flash points such as gasoline or chlorinated and organic solvents is indicated.
- Used oils do not appear to differ significantly in contamination levels according to end-use markets. Similar levels of contamination were measured in used oils that were burned, road oiled and re-refined.

* The new used oil rules are somewhat more lenient. Used oil is subject to the full hazardous waste rules due to the ignitability characteristic only if the flash point is less than 100 °F (see Table 2).

Table 1
Concentration of Potentially Hazardous Constituents in Waste Oil[1]

	Total Samples Analyzed	Samples with Detected Contaminants		Mean Concentration 2/ (ppm)	Median Concentration 3/ (ppm)	Concentration at 75th Percentile 3/ (ppm)	Concentration at 90th Percentile 3/ (ppm)	Concentration Range (ppm)	
		Number	Percent					Low	High
Metals									
Arsenic	537	135	25	17.26	5	5	18	<0.01	100
Barium	752	675	89	131.92	48	120	251	0	3,906
Cadmium	744	271	36	3.11	3	8	10	0	57
Chromium	756	592	78	27.97	6.5	12	35	0	690
Lead 4/	835	760	91	664.5	240	740	1,200	0	21,700
Zinc	810	799	98	580.28	480	872	1,130	<0.5	8,610
Chlorinated Solvents									
Dichlorodifluoromethane	87	51	58	373.27	20	160	640	<1	2,200
Trichlorotrifluoroethane	28	17	60	69,935.88	160	1,300	100,000	<20	550,000
1,1,1-Trichloroethane	616	388	62	2,800.41	200	1,300	3,500	<1	110,000
Trichloroethylene	608	259	42	1,387.63	100	200	800	<1	40,000
Tetrachloroethylene	599	352	58	1,420.89	106	600	1,600	<1	32,000
Total Chlorine	590	568	96	4,995	1,600	4,000	9,500	40	86,700
Other Organics									
Benzene	236	118	50	961.2	20	110	300	<1	55,000
Toluene	242	198	81	2,200.48	380	1,400	4,500	<1	55,000
Xylenes	235	194	82	3,385.54	550	1,400	3,200	<1	139,000
Benzo(a)anthracene	27	20	74	71.3	12	30	40	<5	660
Benzo(a)pyrene	65	38	58	24.55	10	12	16	<1	405
Naphthalene	25	25	100	475.2	330	560	800	110	1,400
PCBs	753	142	18	108.51	5	15	50	0	3,800

1. Results determined for the analyses of 1,071 used oil samples.
2. Calculated for detected concentrations only.
3. For purposes of determining median and percentile concentrations, undetected levels were assumed to be equal to the detection limit.
4. Used samples collected after 1979 only.

Source: Reference 1.

U.S. EPA REGULATIONS FOR USED OIL

In 1985 the U.S. EPA issued three proposals and one final rule for the regulation of used oil. On Jan. 11, 1985, U.S. EPA proposed under Subtitle C of the RCRA regulations[2] that prohibit the burning of non-industrial boilers of used oil that does not meet specification levels for certain hazardous contaminants and flash point. Final rules were issued on Nov. 29, 1985.[3] The regulations also provide administrative controls to monitor marketing and burning activities. These controls include recordkeeping requirements and U.S. EPA notification of used oil activities, including an invoice system for shipments. The specifications for used oil that may be burned in non-industrial boilers without regulation are listed in Table 2.

Table 2
Used Oil Fuel Specification for Oil that May Be Burned in Non-Industrial Boilers

Constituent/Property	Allowable Level for Burning without Regulation
Arsenic	5 ppm maximum
Cadmium	2 ppm maximum
Chromium	10 ppm maximum
Lead	100 ppm maximum
Total Halogens	4,000 ppm maximum
Flash Point	100°F minimum

Source: Reference 3, p. 49181.

Also in the Nov. 19, 1985 *Federal Register*,[4] the U.S. EPA issued a proposed rule to establish standards for used oil that is recycled, or "recycled oil." These standards apply to generators and transporters of recycled oil and owners and operators of used oil recycling facilities. The standards would include tracking requirements when used oil is shipped off-site for recycling and facility management requirements when used oil is stored prior to recycling. Recycled oil used as fuel would be subject to certain regulations except that fuel meeting the specifications listed in Table 2 for toxic contaminants and flash points would be exempt from regulations. Uses of recycled oil that constitute disposal would be regulated as land disposal, and road oiling would be prohibited.

The third proposed rule, also issued in the Nov. 29, 1985 *Federal Register*,[5] would list used oil as a hazardous waste. The effect of the listing, if promulgated, would be to control the treatment and disposal of used oil (as well as its transportation, accumulation or storage prior to treatment or disposal) by subjecting it to full hazardous regulation under Subtitle C of RCRA. At the same time, most used oil that is recycled would be subject to the special management standards of the previously mentioned proposed standards for recycled oil.

In the following sections, expected trends in used oil composition and management practices resulting from the proposed and final rules are summarized.

CHANGES IN USED OIL COMPOSITION

The burning regulations include specifications for metals, total halogens and flash point for oil burned as fuel. Because of these regulations, the concentrations of hazardous materials in used oil will be reduced, thus reducing the risk to human health and the environment.

Most of the contaminants in used oil are the result of normal oil usage. However, significant quantities of some contaminants sometimes are introduced as a result of carelessness or intentional mixing.

Chlorinated solvents make up a major group of contaminants in used oil. They are not a normal component of automotive oil but often are introduced by careless practices. For example, automobile mechanics may pour solvents into tanks used primarily for storing used automobile oils.

Measuring total chlorine is one method for assessing the presence of chlorinated solvents. The 1983 baseline data indicate typical chlorine concentrations range from 1,000 to 5,000 ppm. However, the total chlorine content of some samples that were identified as oil were as high as 40%. It is probable that these materials were not oils at all, but rather solvents. It is expected that many industries, when faced with higher disposal costs because of mixing solvents with used oils, will modify these practices to keep oils and solvents segregated to the best of their ability and therefore continue to manage the oil under the special used oil rules rather than the full hazardous waste rules.

Most metals in used oil are the result of the oil's original use. Metals concentrations in oil can be reduced only by blending. Even with blending at a 9:1 ratio, many oils will not meet specifications.

One of the major heavy metal contaminants in used oil is lead. In the baseline study, the lead concentration in used oil ranged from 0 to 21,700 ppm. The high levels were most common in crankcase oils in samples taken in the early 1970s or from oils taken from leaded gas-burning engines. Samples taken in the 1980s generally had levels between 100 and 1,200 ppm. As stated earlier, the major source of lead in automobile oil is the lead in gasoline. As the lead in gasoline continues to decrease (a tenfold reduction from 1983 is expected in early 1986), the lead level in used oil is expected to decrease almost proportionately.

CHANGES IN USED OIL FLOW THROUGH THE WASTE MANAGEMENT SYSTEM

Several changes are expected in used oil flows through the management system. The U.S. EPA has prepared a Regulatory Impact Analysis (RIA) of its proposed standards for the management of used oil.[6] The estimated total national annualized cost of regulation is $168 million. The U.S. EPA predictions of how these costs (and regulatory constraints) affect supply and demand for used oil in different markets are shown in Table 3. A total increase in recycling of 100 million gallons is expected. The establishment of fuel standards is expected to shift recycled oil to controlled burners. Although the U.S. EPA study does not predict any burning in hazardous waste incinerators, information obtained from industrial sources indicates that significant quantities also may be managed in this way, particularly oils recovered from treatment facilities and various types of oil/water separators.

The use of used oil as a dust suppressant is banned by the proposed rules. This displaced oil (currently 69 million gallons per year) is expected to be used as both re-refining feedstocks and fuel. Re-refining, which generally is considered a wise reuse practice by most segments of society, is expected to increase from 85 to 135 million gallons per year. There is, however, some question about whether re-refiners can economically survive in a tight lube oil market and with higher operating costs than the fuel oil processors who compete for the same oil.

The RIA has estimated impacts on used oil generation, collection and processor facilities. For industrial generators, used oil management costs are usually very minor when compared to the industry's production processes. It is expected that used oil still will be sold to collectors and processors but for a lower price because of the collector and processor costs of regulatory compliance. The generation from industrial generators is not expected to change significantly as a result of the regulations.

The impacts of regulations on non-industrial (automotive) generators are expected to be greater. The U.S. EPA has assumed that since automotive oil changes will cost more, more homeowners will change their own oil. This impact could result in more oil being dumped. The U.S. EPA estimates that full implementation of the rules will increase these homeowner oil changes by 12 million gallons per year.

Table 3
Effect of Regulation on Market Flows of Used Oil
(Million gallons per year)

	Baseline	Regulatory Impact
Burning		
Industrial Boilers	249	185
Asphalt and Cement Kilns	94	309
Non-industrial Boilers	121	117
Diesel Engines	15	15
Space Heaters	34	34
On-site Boilers	73	48
Total Burned	586	708
Re-refining		
Lube Oil	59	101
(total re-refined)	(85)	(135)
Non-fuel Industrial	36	40
Road Oiling	69	0
Disposal	405	305
Total	1,155	1,155

Source: Reference 4, p. 49247.

Collectors (particularly small collectors) are expected to experience the most significant changes in the industry structure resulting from the U.S. EPA regulations. It is estimated that approximately 473 small and medium-sized collectors will find it uneconomical to continue operating as small independent businesses. Although these 473 collectors represent approximately 50% of the used oil recycling industry, they currently handle only approximately 10% of the volume of oil entering the recycling system. Initially, some oil may not be collected as facilities adjust to the changes imposed by the regulations. In the long run oil will be collected, but the nature of the collection function is likely to be very different after regulation.

Some of the small collectors (an estimated 155) are expected to grow or become part of larger businesses and thus be able to absorb the costs of the U.S. EPA regulations.

The U.S. EPA has optimistically estimated that the flow of used oil to re-refiners will grow by 59% as a result of the new regulations. This means the equivalent of six new facilities will be opened (there are now 13).

Minor and major processors are not likely to change drastically as a result of the used oil regulations, although it is estimated that 12 out of the current 115 minor processors and two of the current 25 major processors may be involved in closures.

CONCLUSIONS

The expected trends in used oil composition and management following the promulgation of the 1985 proposed regulations are summarized as follows:

- Reduction of lead in automotive oils as a result of the removal of lead from gasoline
- Reduction of chlorinated solvents in waste oil because of improved handling practices
- Reduction in the quantity of used oil burned in industrial and non-industrial boilers
- Increase of burning in asphalt plants and cement kilns
- Elimination of road oiling with used oil
- Large potential increase in re-refining of used oil
- Increase in total used oil burned because of constraints on placing liquids in secure landfills
- Decrease in total disposal of used oil, but with probable increase in dumping by do-it-yourself automobile oil changers

The overall used oil regulations and allowable lead level in gasolines will result in a significantly better used oil management system from an environmental perspective. Burning will be more closely controlled, and the oils burned will be of much higher quality.

In the past, generators were very careless and often purposely mixed hazardous wastes into oil. The new rules should modify this behavior substantially, resulting in more oils that are contaminated only through normal use. With the planned lead reduction, these levels of contamination are quite low compared to earlier levels of contamination resulting from purposeful mixing.

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