Recycling Used Lubricating Oil at the Deep Space Stations

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Current practice at the Deep Space Stations (DSSs) is to change the diesel engine lubricating oil after 1000 hours of operation. In 1977, the Canberra, Australia, station (DSS 43) conducted a test to extend engine oil life by recycling the oil through a centrifuge at the 1000-hour periods. Due to massive sludge buildup in the engine, the test was terminated after the oil had been recycled four times. This report provides a comparison on the recycling methods used in the DSS 43 test and the basic requirements which could favor recycling of oil for continuous reuse. The basic conditions for successful recycling were compared to the conditions that exist in the DSN. This comparison shows that to recycle used oil in the DSN would not only be expensive but also nonproductive.

I. Introduction

It is reasonable to assume that each time an engine or equipment lubricating oil change is made at the deep space stations, there is a possibility that the used oil could be recycled for a cost savings and as a conservation measure. The possibility will increase in importance if oil shortages become more acute, while at the same time more stringent environmental controls on the disposal of used oil are effected.

Interest in recycling used oil is not confined to the deep space stations. Large oil consumers, oil filter and purification manufacturers and, in general, environmental conservationists, are also interested in recycling used oil. Understandably, this interest is not shared by lubricating oil manufacturers.

The purpose of this report is to determine whether conditions favor recyling used oil at the deep space stations. The data used in the cost estimates are based on the Commercial Power Feasibility Study for Madrid Tracking Stations, 1980 (Ref. 1), and the DSS 43 Lubricating Oil Recycling report, 1977 (Ref. 2).

II. Methods of Recycling Lubricating Oil

In mid-1976, DSS 43 in Canberra, Australia, conducted a program to extend the life of the lubricating oil used in the four G399 Caterpillar diesel engines used to drive the powerhouse alternators. The method employed was to clean the used oil in situ through a centrifuge after each 1000 hours of engine operation. Cleaning was done with the engine running and the time taken for each cleaning was about 40 hours. Samples were taken after each cleanup and tested at the British Petroleum Oil Company laboratory for suitability and signs of increased wear rates. The results reported by the British Petroleum Oil Company indicated that the oil was still within recommended limits after 4000 hours of use. However, the results obtained were questionable since heavy sludge formation and filtering system damage were detected during the first 5000-hour inspection. The program was therefore terminated and the recommended oil change sequence was resumed.

Compared to commercial or large-scale consumer methods (Ref. 3) of rerefining used lubricating oil, the DSS 43 method was only an extention of continuous partial filtration and cannot be accepted within the context of a recycling process. A typical method of recycling oil is to filter, rerefine, repurify, and test the quality before reuse, as shown schematically in Fig. 1. This process represents a miniature lube blending plant (in terms of equipment and operations) with additional filtration for the feedstock and sludge disposal system. This typical process is the minimum required to ensure that the reclaimed oil can meet the following:

(1) Lubricant and lubrication requirements

(2) Expected quality of good lubricating oil

(3) Disposal of sludge

III. Lubricant and Lubrication Requirements

Whether new or refined, oil is designed and blended to a specification that will fulfill the lubrication functions that the oil is expected to provide. These requirements are summarized as follows:

(1) Lubricate: To function hydrodynamically on all parts, to reduce friction, heat, and wear when introduced as a film between solid surfaces receiving a continuous flow of fluid lubricant. To function as a thin lubricant on parts such as in an oil bath.

(2) Clean: To keep parts and surfaces mechanically clean, thus preventing wear and improving performance.

(3) Seal: To prevent foreign material from entering the parts and surfaces.

(4) Cool: To transfer the heat from the parts to a cooling medium.

(5) Protect: To shield all parts from buildup of foreign material, corrosive attacks and degradation of the lubricant itself.

IV. Expected Quality of Good Lubricating Oil

Virgin lubricating oils extracted from mineral sources, whether straight-run or multiblend, cannot meet all lubrication requirements. Similarly, rerefined oil cannot be expected to retain its original physical properties and function as well as in its original application. Just as natural new lubricating oils are treated as base stocks, the rerefined oil must be considered as base stock, and can be reblended to the required specification. The reblending process might take the sequence of (Ref. 4):

(1) Reblending with other base stocks (including synthetic base oils) to meet viscosity and volatility standards.

(2) Adding of detergents to:

  (a) Prevent gum buildup.

  (b) Clean away dirt and scavenge engine parts of sludge.

  (c) Suspend fine particles.

  (d) Disperse soluble residues and insolubles.

  (e) Prevent sludge formation.

  (f) Neutralize corrosive acids.

  (g) Prevent rust corrosion.

  (h) Ensure adhesion to moving parts.

(3) Adding of chemicals to:

  (a) Reduce rate of wear at critical areas.

  (b) Improve viscosity to improve lubrication strength.

  (c) Improve thermal stability.

  (d) Reduce emulsification.

  (e) Widen margin of applications.

  (f) Improve flexibility.

  (g) Reduce consumption.

(4) Adding inhibitors to:

  (a) Slow down oxidation.

  (b) Reduce metal reaction.

  (c) Increase equipment life.

  (d) Improve performance.

V. Confidence in Using Recycled Oil

No matter how good rerefined oil is, there is at present a negative feeling because it is not new. This lack of confidence stems from the fact that it is impossible to physically or chemically remove all the contaminants that entered the oil when it was originally used. Because of these residual contaminants, it is difficult to maintain the lubrication warranty requirement for the equipment, and the warranty may be invalidated.

Users of rerefined oil will generally downgrade its applications by running on a shorter oil change cycle, or by using it as a topping-up oil. To ensure that such applications can achieve a successful degree of lubrication, a controlled schedule of oil change and topping must be planned. Table 2 shows such a schedule of an engine's typical oil change cycle and topping-up procedure.

VI. Incentive to Recycle

With proper rerefining processes and careful scheduling in using rerefined oil, the useful life of the oil can be extended indefinitely; hence, potential savings could be realized. As shown in Table 1 for a five-year period, the amount of oil saved is about 52% of the total oil used. As far as the DSN is concerned, the incentive to recycle oil will be the net savings the effort can provide.

At the Madrid Tracking Station, the present operating configuration of the power-house requires two G399, three G398 diesel engine generators, and occasionally others. At a 1000-hour change cycle, these engines will need about eight oil changes per year. G399 requires 420 liters (110 gal) and G398 requires 345 liters (90 gal) of oil per change plus approximately 50% more for topping-up between each change (Appendix A). The total need per year is about 28,350 liters (7500 gal) consisting of:

G399	2 X 8 X 630 =	10,080 liters (2670 gal)
G398	3 X 8 X 520 =	12,480 liters (3300 gal)
Others		5,790 liters (1530 gal)
		28,350

Oil saved per year by rerefining

0.52 X 28,350 = 14,742 liters

Potential dollar savings @ $0.40/liter

14,742 X $0.40 = $5,897

The above figure ($5897) does not consider the costs of the recycling process and sludge disposal.

The most desirable way to recycle this used oil would be to have it commercially rerefined and reblended to the original specifications. Since the quantity involved is small, the processors contacted were not interested in performing this service. Alternatively, the used oil could be stored and processed periodically with on-site rerefining equipment. The equipment envisaged will be about a 220 liter-per-hour processing unit fully equipped with storage, blending, and testing facilities. Although such equipment is not readily available, most vendors contacted indicate that the equipment could be built to customers' requirements for about $40,000, plus $20,000 for installation, making a total capital cost of about $60,000.

Based on a large plant (6500 liter/hr), the operating cost per liter for high-level pretreatment (vacuum distillation and solvent extraction) is about $0.08. With a small unit, the pretreatment costs can be $0.10 per liter. Additives and other miscellaneous costs add $0.05 per liter and costs for disposing of sludge at a city sanitation dump add $0.05 for a total operating cost of about $0.20 per liter. Based on Madrid data, the operating cost for rerefining the used oil is about $2,948 per year. The net savings per year is about $2,949. Since the capital investment is about $60,000, the savings do not justify rerefining used oil in the DSN under existing circumstances.

VII. Disposal of Sludge

One of the main problems associated with recycling used oil is the disposal of sludge. Since used oil has already been classified as a hazardous waste, the sludge is considered more hazardous and the disposal will have to conform to the conditions stipulated in the Resource Conservation and Recovery Act of 1976, Public Law 94-580 Subtitle C. This act established the standards for treatment, transportation, storage, and disposal of hazardous waste. The act has, in effect, ruled out the common methods of sludge disposal on land or burning in incinerators, and probably increases the problems of sludge disposal beyond the ability of the deep space stations to cope with them. Therefore, the DSN may require outside assistance in the disposal of sludge.

VIII. Alternate Use of Recycled Oil

The above discussions indicate that it would be impractical for the DSN to recycle used oil as a lubricant. If the used oil were to be of any value to the stations, it would have to be used as a fuel mix for the diesel engines. Based on used oil and fuel data from the Madrid stations, the used-oil-to-fuel ratio is about 0.4% by volume (Appendix B). This low percentage of oil-to-fuel ratio will require only simple processes of dilution, mixing and settling to achieve the purpose shown in Fig. 2. A study done by the U.S. Environmental Protection Agency indicated that the technical and environmental factors affecting used oil reuse as a fuel must be considered. These pertinent factors would vary with each situation, but as far as the stations are concerned, they should be reasonably easy to overcome.

IX. Recommendation and Conclusion

The recycling of used lubricating oil is an entirely new technology and current equipment available for small systems for this recycling process is still in the experimental stage. Also, the expertise required to operate such a system would be equivalent to that of a lubricating oil blending plant, and this expertise is not available at the stations. This report shows that there are no incentives at the stations to recycle diesel engine lubricating oil. The simplest method to recover the value of the used oil would be to use it as a fuel mix. Since the quantity involved is small, the pertinent problems normally associated with using the recycled oil as a fuel mix should be reasonably easy to overcome. Further study is continuing.

References

1. "Commercial Power Feasibility Study for Madrid Tracking Stations". Technical Study Report Prepared for DSN Facility in Spain, Sereland Inc., Madrid, 1980.
2. Technical Report – TR 77-2 "DSS 43 Lubricating Oil Recycling" issued by: Network Support Facility, DSS 43, Canberra, Australia, February 1977.
3. Blatz, F. J., and Pedall, R. F., "Rerefined Locomotive Engine Oils and Resource Conservation", Vol 35, pp. 620-621, *ASLE Lubricating Engineering,* November 1977.
4. Lancaster, R., "Description of Lubricating Oil Terms and What They Mean," Presentation paper of Torco Oil Company, Santa Fe Springs, Calif.

Table 1. Average oil savings per year through recycling based on G399 Caterpillar engine (five-year period total 40 oil changes)

Engine hours run	New or recycled oil	Lubrication requirement: Oil change, liters per 1000 hrs	Lubrication requirement: [a]Total top-up liters per 1000 hrs	[b]Oil losses due to recycling liters	Remarks
0	New	420	0	0	First year savings
	Recycled	0	0		Total new oil used = 2688 liters
1000	New	0	210	0	Total re-refined oil used = 2352 liters (oil saved)
	Recycled	0	0		
2000	New	294	0	84	Total quantity of oil used if no recycling = 5040 liters
	Recycled	126	210		
3000	New	294	0	84	Percent oil savings through recycling $= \frac{2352}{5040} \times 100 = 46.7\%$
	Recycled	126	210		
4000	New	294	0	84	
	Recycled	126	210		Five year savings
5000	New	294	0	84	Total new oil used = 12096 liters
	Recycled	126	210		Total re-refined oil used = 13104 liters
6000	New	294	0	84	
	Recycled	126	210		Percent oil savings through recycling
7000	New	294	0	84	$= \frac{13104}{25200} \times 100 = 52\%$
	Recycled	126	210		
8000	New	294	0	84	
	Recycled	126	210		
One-year period	Total new	2478	210	0	
	Total recycled	882	1470	588	
Five-year period	Total new	11886	210	0	
	Total recycled	4914	8190	3276	

[a]Average oil consumed
[b]Assume 80% recovery in recycling

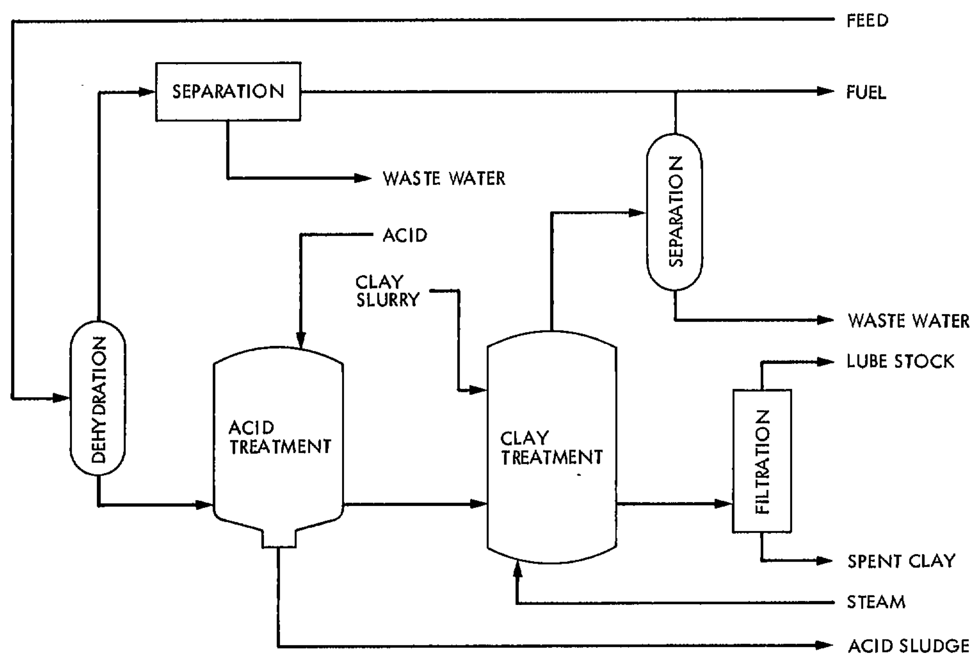

Fig. 1. Rerefining by acid/clay process. Process starts with dehydration to remove any water and solvents from the feed; followed by acid treatment to "break down" contaminants into acid sludge. The acid treated oil passes through a clay bed to remove color bodies and remaining contaminants. The spent clay is removed by filtration, producing a quality base oil product to be blended to specification.

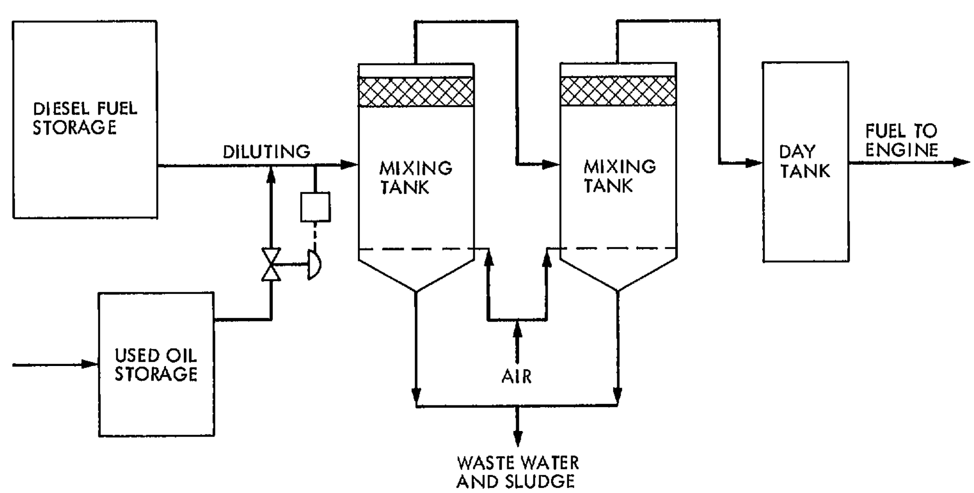

Fig. 2. Fuel and oil mixing process. Process starts with the used oil being diluted with diesel fuel in the appropriate proportion; followed by mixing and settling. Air is used to provide a more homogeneous mixture as well as a means of coalescing water droplets in the mixture. Wire mesh coalescers at the top of the mixing tanks coalesce any water/sludge suspended in the mixture and drop them to the bottom to be drained during settling.

Appendix A

Lube Top-Up Requirements

DSS 14 lubricating oil consumed Jan-Aug 1980 = 2250 liters (595 gal)

Hours engines run same period: Four G399[1] = 3170 hours; Four G398[2] = 1493 hours

$$\text{Total equivalent G399 engine run} = \left(\frac{500}{750} \times \text{G398 equivalent hours}\right) + 3170 \text{ hours}$$

$$= \left(\frac{500}{750} \times 1493\right) + 3170 \text{ hours}$$

$$= 995 + 3170 \text{ hours}$$

$$= 4165 \text{ hours}$$

$$\text{Equivalent oil consumed per 1000 hours for four G399} = \frac{2250}{4.165}$$

$$= 540 \text{ liters (143 gal)}$$

$$\text{Therefore one G399 consumed} = \frac{540}{4} \text{ liters}$$

$$= 135 \text{ liters (36 gal)}$$

NOTE: 135 liters represents about 32% of a G399 engine oil change under normal operations. With recycling, a 50% quantity is assumed to allow for higher handling losses.

[1] G399 rated at 750 kW.
[2] G398 rated at 500 kW.

Appendix B

Diesel Fuel With Used Oil Mixture

Assumption (Data based on Madrid Tracking Station):

Total lubricating oil usage	= 28350 liters/year
Total lubricating oil consumed	= 28350 × 0.33
	= 9356 liters/year
Used lubricating oil available for fuel	= 18994 liters/year
Total fuel oil consumption	= 4,722,580 liters/year

Percent oil-to-fuel mixture

$$= \frac{18994}{(4{,}722{,}580 - 18994)} \times 100\%$$

$$= 0.4\%$$