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ESTABLISHMENT OF FACTORIES IN DEVELOPING COUNTRIES FOR THE RE-REFINING OF AUTOMOTIVE LUBRICATING OIL 1/

- A Preliminary Guide -

prepared by

secretariat of UNIDO

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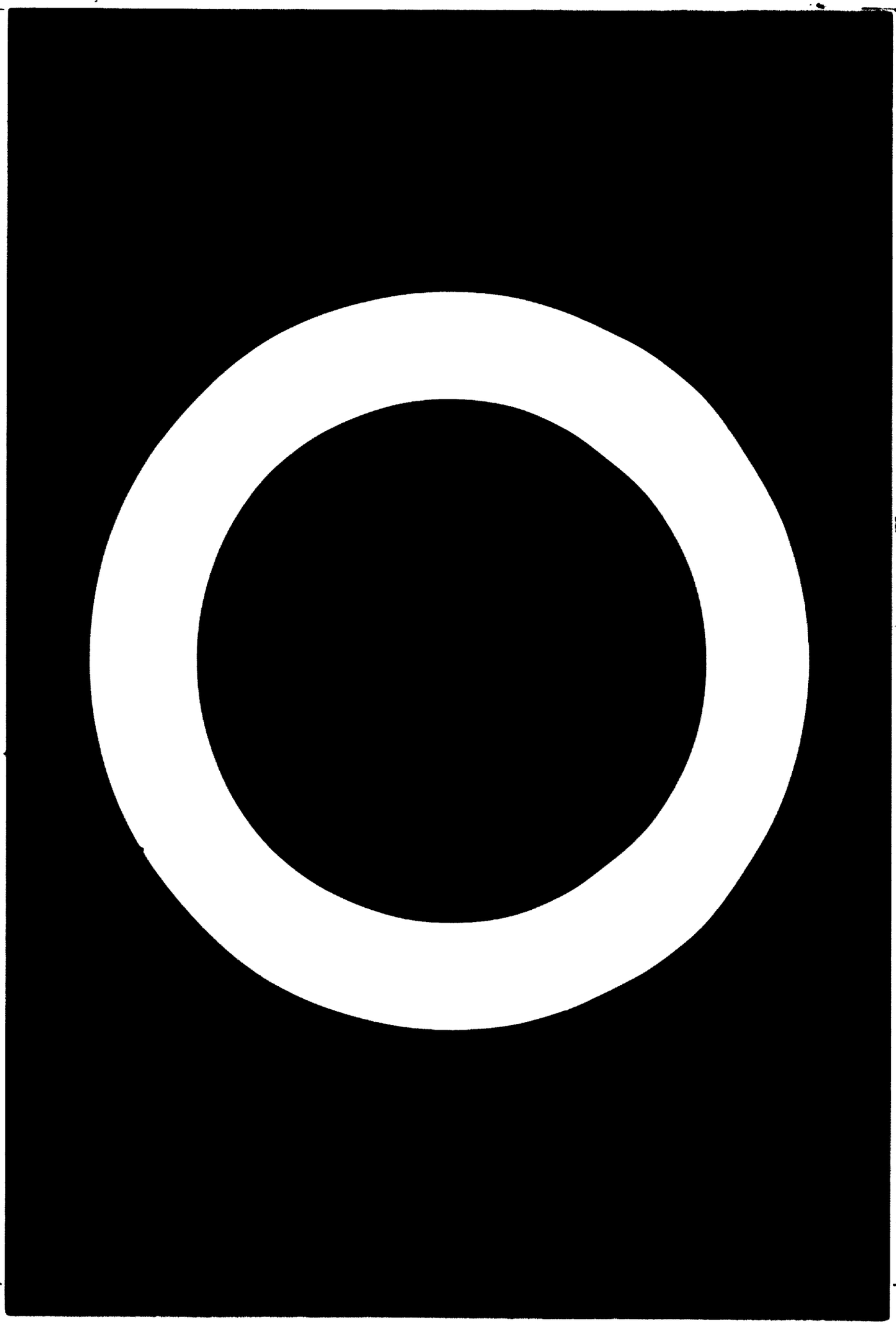

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FOREWORD

This brief guide has been prepared as an illustrative example of a "factory establishment manual". Technical and financial data contained herein have been synthesized from various sources and must not be taken as accurately reflecting a practical technical process or probable financial performance. The purpose is rather to indicate the parameters which need to be studied in an actual case and their approximate inter-relationships. The paper thus provides a rough guide to potential project developers. Sources of more precise information and technical co-operation are identified in Section 5.

Comments on the concept and approach of this document, as well as its content, are invited and may be sent to Factory Establishment and Management Section - Industrial Operations Division, UNIDO, A-1011 Vienna, Austria. Expressions of interest in specific topics for future publications of similar nature are also welcome.

1. SUMMARY

The recent large increases in petroleum prices provide a great incentive to examine the feasibility of recycling used automotive lubricating oils. As a provisional rule of thumb we estimate that each 10,000 cars, trucks, and buses on the average, will use 1000 tons of lubricating oil per annum. Under certain conditions it may be feasible to recover and reprocess one-third to one-half of the total, yielding perhaps 300 tons of high quality "new" oil. Reprocessing units with capacity of as low as 200 tons per year are commercially available; technical and logistic operations are not overly difficult. The economics are promising, especially for somewhat larger reprocessing units.

There is, however, at least one critical factor: that is the fundamental importance of the necessary commercial arrangements (both supply and marketing), which may require governmental intervention to ensure realization. Governments have lent their support to recycling programmes in some countries because of the significant foreign exchange advantage implicit in such schemes and because of the potential reduction of environmental damage otherwise caused by uncontrolled disposal of waste oils.

Since the manufacturing equipment required is relatively simple, most of the components can be produced in many developing countries, thus reducing initial plant cost and limiting the foreign exchange needed to set up a plant.

Thie guide provides a preliminary technical, commercial, and financial profile for four (arbitrary) sizes of plant: 200, 500, 5,000 and 10,000 tone per year output capacity. Estimated total investment ranges from about $65,000 to $750,000 and annual return on investment from (6%) to 64%, under the assumptions used. Naturally, a special study is needed to determine realistic prospects for such a project in a particular market.

2. MARKETING, COMMERCIAL AND REGULATORY ASPECTS

2.1 Examples of Current Interest in Re-refining

Re-refining is already carried out in a number of countries such as Germany, The United Kingdom, Malaysia, and India. In UK the industry supplies independent distributors although there has been discussion of involving the major oil companies, to increase the marketing coverage achieved. In India, relatively low-cost equipment and processes have been developed by the Indian Institute of Petroleum. The Government has been considering establishment of a large scale re-refining company as a joint subsidiary of several major oil companies. In Germany a subsidy is paid to licensed collectors; this is financed by a tax on new lubricating oil. In the United States, a number of incentives have been provided through the National Oil Recycling Act.

2.2 Obtaining A Supply of Used Oil

As indicated in Section 1 it is necessary to examine the local industry structure carefully in order to ensure that adequate supplies of used motor oil can be obtained at reasonable cost. As a starting point it is assumed that the new enterprise will collect used oil in barrels from gasoline service stations, garages, and fleet motor pools within 25 or 50 kilometers from the plant.

Our rough estimating figures of used oil availability can be translated into the following table of potential re-refining capacity for various numbers of vehicles in use:

No.vehicles in metropolitan area	Avg.No.tons of oil used p.a.	Est.No.tons used oil potentially available	Est.plant output re-refined oil (tons)
10,000	1,000	350	280
50,000	5,000	1,500	1,200
100,000	10,000	3,500	2,800
250,000	25,000	8,500	6,800

Although it is thought that much used oil is presently dumped, there is a possibility that a new re-refining operation would encounter competition from rival operators (with or without licenses). Although supplies of used oil from fleet operators can often be secured under contract arrangements, public bodies may be required to request new tenders at regular intervals, such as annually.

For supplies from gasoline and service stations it may be difficult to secure -and more difficult to enforce- any such agreements, depending on local conditions. Consequently it would be of interest to explore possible links with a major oil company to ensure supplies of used oil (as well as in connection with marketing, which is discussed in section 2.2). The possible role of Government regulatory measures is referred to in Section 2.4.

2.3 Marketing and Distribution

A re-refining operation may either limit its operation to producing base stock for bulk sale or may formulate, package and market finished engine oils through the use of purchased additives. Although the second alternative is potentially more profitable, the marketing risks are also greater, and it is likely that the first phase of operation will be limited to production of base stock. 1/

In this case the product may be sold to major oil companies which formulate motor oils locally, or to one or more independent distributors who perform that function on their own account. The ease or difficulty of arriving at practical distribution arrangements is a critical question for success of the project. It may be necessary to seek governmental assistance through an administrative order favoring the partial inclusion of re-refined oil in motor oils distributed by the established firms , or at least their co-operation in distribution of the product. Forgiveness of manufacturing excise taxes may be another necessary incentive, depending upon local cost structures.

/1 This statement should not deter a potential sponsor from investigating the more complex operation. In fact the illustrative financial analyses do include the packaging operation.

If finished engine oils are formulated and packaged in retail units such as half-liter tins or plastic containers, the possible sales and distribution channels are more numerous. But most lubricating oils are probably sold through the major oil company outlets. This means that if a substantial fraction of original oil sales is re-cycled, access to these outlets will almost definitely be required.

2.4 Possible Role of Government Regulatory Measures

In some countries bootleg operators tend to outbid legitimate re-refiners for used oil, and make a profit by performing only a cosmetic treatment before reselling the material as "new" or "re-refined" oil under false labels. This is a potential problem which must be guarded against, if necessary by governmental quality spot checks and disciplinary measures.

Needless to say, the entrepreneur's risk is reduced if such regulations and enforcement means are available from the project's beginning. It is suggested that the Government's interest in, and support for, a proposed project be sought by the sponsor at a fairly early stage. It would be reasonable to discuss the foreign exchange and environmental benefits available to the Government and the range of possible support measures which might be made available. The possibility of manufacturing a substantial portion of the plant equipment locally should be explored, since freight and other savings may be considerable.

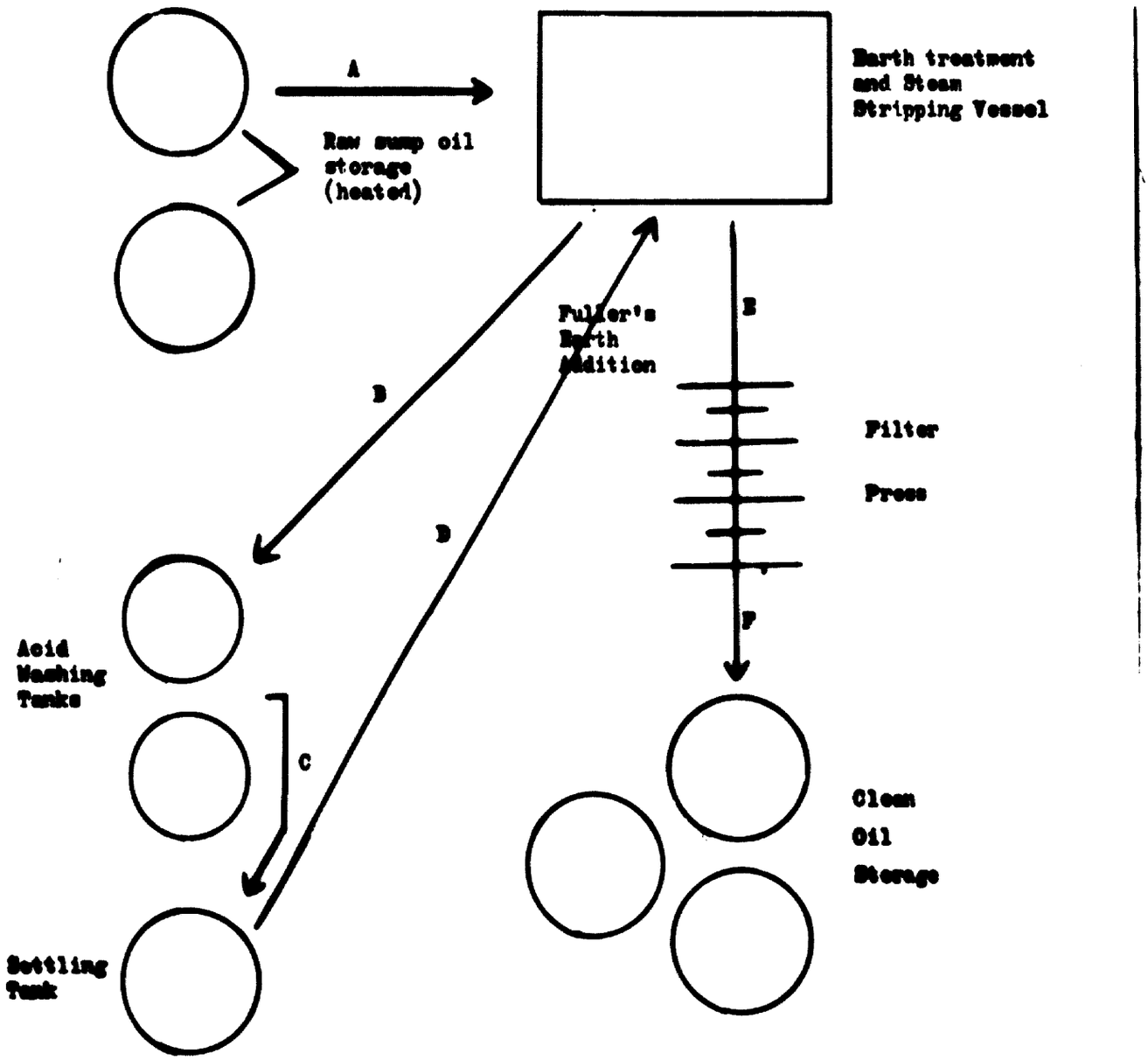
3. THE FACTORY

3.1 Technical Description

This paper limits its consideration to a low-to-medium throughput batch process. Exhibit 1 indicates a typical plant layout and process flow.

After coarse filtration and settling, the used oil is pumped into a pot still where it is dried by heating to about 110°C. The oil

EXHIBIT 1. TYPICAL PLANT LAYOUT AND PROCESS FLOW



is then transferred to an acid wasting tank where, after cooling, it is treated with sulphuric acid. This produces a tarry sludge which is drawn off. Next, excess acid remaining in the oil is neutralized with the minimum amount of caustic soda solution. The oil is transferred back to the pot still, mixed with activated clay and heated to about 280°C. Steam is injected to strip off diluting agents, which are collected in the condenser. The oil is then admitted to a surge tank and passed through a filter press to remove the clay.

This process will produce a high quality mineral oil base stock. Although the process is relatively fool-proof, its effectiveness does depend to some extent on avoiding contamination of the feed stock by cellulose (paint) thinners, fatty oil (cutting oils) and residual (black) fuel oils.

The basic process has been essentially unchanged since the Second World War when it was used as a conservation measure because normal oil supplies were interrupted. The base stock thus produced is a good quality high viscosity index mineral oil. It can be used in formulating internal combustion motor oils with standard additives.

For larger volumes a continuous process is also available and should be evaluated as an alternative for annual capacities in excess of perhaps 10,000 tons.

3.2 Quality Control Requirements

Since marketability through the desired reputable channels depends upon proper quality control, arrangements for necessary regular checking must be made with care. Simple checks can be made in the plant for the most important characteristics, but sophisticated chemical analysis capability must be available for periodic use. The best source may be a standards institute, a specialized petroleum institute, a university laboratory, or another specialized institution.

3.3 Cost of Plant and Input Requirements

We have assumed a plant design in accordance with the process [1] described in Section 3.1, and made very rough estimates of investment and operating costs based on operation at 100% of capacity. Exhibit 2 indicates a build-up of investment cost, Exhibit 3 provides details of the process chemical requirements, Exhibit 4 indicates the assumed break-down of staff requirements. Pro-forma operating results are considered in Section 4.

4. TENTATIVE FINANCIAL ANALYSIS [2]

Using the foregoing information we have prepared a pro-forma operating statement covering the production of lubricating oil base stock. This is presented as Exhibit 5. From these caloulations (although they are only a rough guide) it can be seen that the processing cost per ton of finished product drops substantially with increasing volume from $150 per ton at 200t/a capacity to $35 at 10,000t/a. Thus there is considerable economic incentive to set up a unit at least in the neighborhood of perhaps 1,000 to 5,000 t/a capacity. Although the illustrative figures show high rates of return on investment, it is necessary to make independent estimates for each potential market area. The figures may come out considerably differently.

Exhibit 6 assumes that the re-refining company does go into the formulation and packaging of motor oils instead of just producing base stock. A projection of financial results is given (on a per-ton basis) based on rough estimates of additional costs. It may be seen that profitability at the higher capacities appears very attractive. Of course the selling price and costs all must be carefully analysed in much greater detail, and modified to fit a particular situation. We have only provided a general indication of possibilities. It is also to be noted that the marketing activities associated with this more complex project would probably also require much greater attention.

1/ Technical details of the process description may not be relied upon.

2/ All of the figures are speculative and should be considered useful for illustration only.

EXHIBIT 2. ESTIMATED INVESTMENT ($ X 1,000)

	Capacity 1/			
	200t/a	500t/a	5,000t/a	10,000t/a
Equipment	25	45	180	290
Tanks				
Pumps				
Stripper				
Condenser				
Filter press				
Boiler				
Building and land	20	30	75	110
Fitting, Installation	5	10	30	50
Transport equipment	10	10	30	40
Total Fixed Investment	60	95	315	490
Working Capital	5	13	125	250
Total Investment	65	108	440	740
Batch size (Input of used oil)	400 l .3t	1000 l .9t	10,000 l 9t	20,000 l 18t

1/ One batch per shift, two shifts per day, 300 days per year.

EXHIBIT 3. APPROXIMATE USAGE OF PROCESSING MATERIALS

(for each ton of output, i.e. for each 1,500 liters of used oil input)

	Rate (% by wt)	Amt (kg.)	Est.unit cost ($ per ton)	Est.cost per ton of output ($)
Sulphuric acid	6-8	51-68	200	12
Lime	4	42	60	3
Activated clay	2-3	17-25	50	1
Total average estimated cost of chemicals per ton of output				16

EXHIBIT 4. PERSONNEL REQUIREMENTS

	200 t/a	500 t/a	5000 t/a	10,000 t/a
Supervisor	2	2	2	2
Semi-skilled labor	2	2	3	3
Driver	1	1	2	3
Technician			1	1
Accountant			1	1
Unskilled Labor			1	2
	5	5	10	12

EXHIBIT 5. PRO-FORMA OPERATING STATEMENT - PRODUCTION OF BASE STOCK ONLY ($ X 1000)

	Capacity a/ b/			
	200 t/a	500 t/a	5000 t/a	10,000 t/a
Sales Revenue @ $150/ton	30	75	750	1500
Cost of materials				
Used oil @ $15/ton c/	4	10	100	200
Acid, lime and clay	3	8	80	160
Labour and supervision	10	15	25	40
Depreciation	5	8	30	50
Utilities	4	8	25	40
Interest and Taxes (except income tax)	5	8	20	35
Other operating costs	3	5	15	25
Total cost of goods sold	34	63	295	550
Profit before income-tax	(4)	13	455	950
Return on investment (assuming 50% income tax)	(6%)	6%	52%	64%
Collection and Processing Cost per litre of finished base stock d/	$.135	$.094	$.035	$.032
per ton of output	$150	$104	$39	$35
Approximate break-even point (% of capacity)	117%	77%	28%	17%

a/ Figures assume operation at 100% of capacity.

b/ Plant capacities are output ratings.

c/ Assumed yield is 75% of used oil input.

d/ Specific gravity of the oil is assumed to be 0.90.

EXHIBIT 6. PRO-FORMA OPERATING SUMMARY - PRODUCTION OF COMPLETELY FORMULATED MOTOR OILS

($ per ton)

	Plant Output Capacity			
	200 t/a	500 t/a	5000 t/a	10,000 t/a
Sales Revenue (per ton)	500	500	500	500
Cost of Used Oil a/	20	20	20	20
Collection and Processing to yield base stock b/	150	104	39	35
Additives and formulation c/	190	150	150	130
Packaging in plastic bottles (½ and 1 litre)	125	100	90	45
Marketing and distribution	60	50	25	20
Cost of Sales	545	424	274	250
Profit before Income Tax	(45)	76	226	250
Profit as % of Sales (assuming 50% income tax)	(4%)	8%	23%	25%

a/ Since the process yield is assumed to be 75%, each ton of finished product requires 1,1/3 tons of used oil (@ $15 per ton)

b/ From Exhibit 5

c/ Includes about 15% additive @ $800 per ton.

5. FOLLOW-UP ACTION APPROACH

It is suggested that a local market survey -both supply and sales- be made before any technical design work is started. The survey would check approximate supply and cost of used oil which could readily be collected on a continuous basis and the characteristics of possible distribution schemes which might prove feasible. If the difference between estimated cost and selling price at a conservative volume estimate will easily cover the estimated processing costs in a plant of that capacity, and if Government attitudes are positive, then it is probably worthwhile to consider details of a possible plant design.

Further information on technical processes can be obtained from various sources. The following have recently informed UNIDO of their interest in providing services to sponsors in developing countries:

- National Research Development Corporation of India, 61 Ring Road, New Delhi, India;
- Pressure Lubricants, Stevinson Wharf, Northfield Road, Rotherham, Yorkshire, England.

If requested by a Government (and if finances are available) UNIDO will provide technical co-operation services in connection with market studies, feasibility investigations or physical implementation of a re-refining project. Interest may be communicated through the UNDP Resident Representative or direct to the Factory Establishment and Management Section, Industrial Operations Division.

C. BIBLIOGRAPHY

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- To Hydrotreat Waste Lube Oil, S.R. Bethea et al, Hydrocarbon Processing, September 1973
- The Re-refining of Used Lubricating Oil, A.H. Chatwin, Petroleum Review, October 1975
- Waste Lubricating Oil Research. An Investigation of Several Re-refining Methods, M.L. Whisman, et al, Bureau of Mines, Washington D.C., 1974
- Recycling Technologies, ACE/RT/No. 1, UNIDO, December 1974
- The Waste Oil Problem, R. Sager, ICIS, UNIDO, January 1977 1/

b) Other UNIDO publications providing similar scope and intended for potential sponsors of industrial projects (selected)

- Guidelines for the Production and Marketing of Acrylic Sheet in Developing Countries, United Nations Sales No. E.71.II.B.21
- Technical and Economic Aspects of the Oil Palm Fruit Processing Industry, United Nations Salos No. E.74.II.B.10
- A Fertilizer Bulk Blending and Bagging Plant, United Nations Sales No. E.76.II.B.2

c) Selected UNIDO publications providing specialized management guidance for establishing new factories

- Guidelines for the Acquisition of Foreign Technology in Developing Countries, (with special reference to technology licence agreements), United Nations Sales No. E.73.II.B.1
- Contract Planning and Organization, United Nations Sales No. E.74.II.B.4
- Closing the Factory Establishment Gap, UNIDO/IOD.105, 10 August 1977

1/ Dr. Sager has also prepared a number of survey reports for UNIDO on the prospects for establishing re-refining plants in individual countries. Those (unpublished) reports have been consulted in the preparation of this document.

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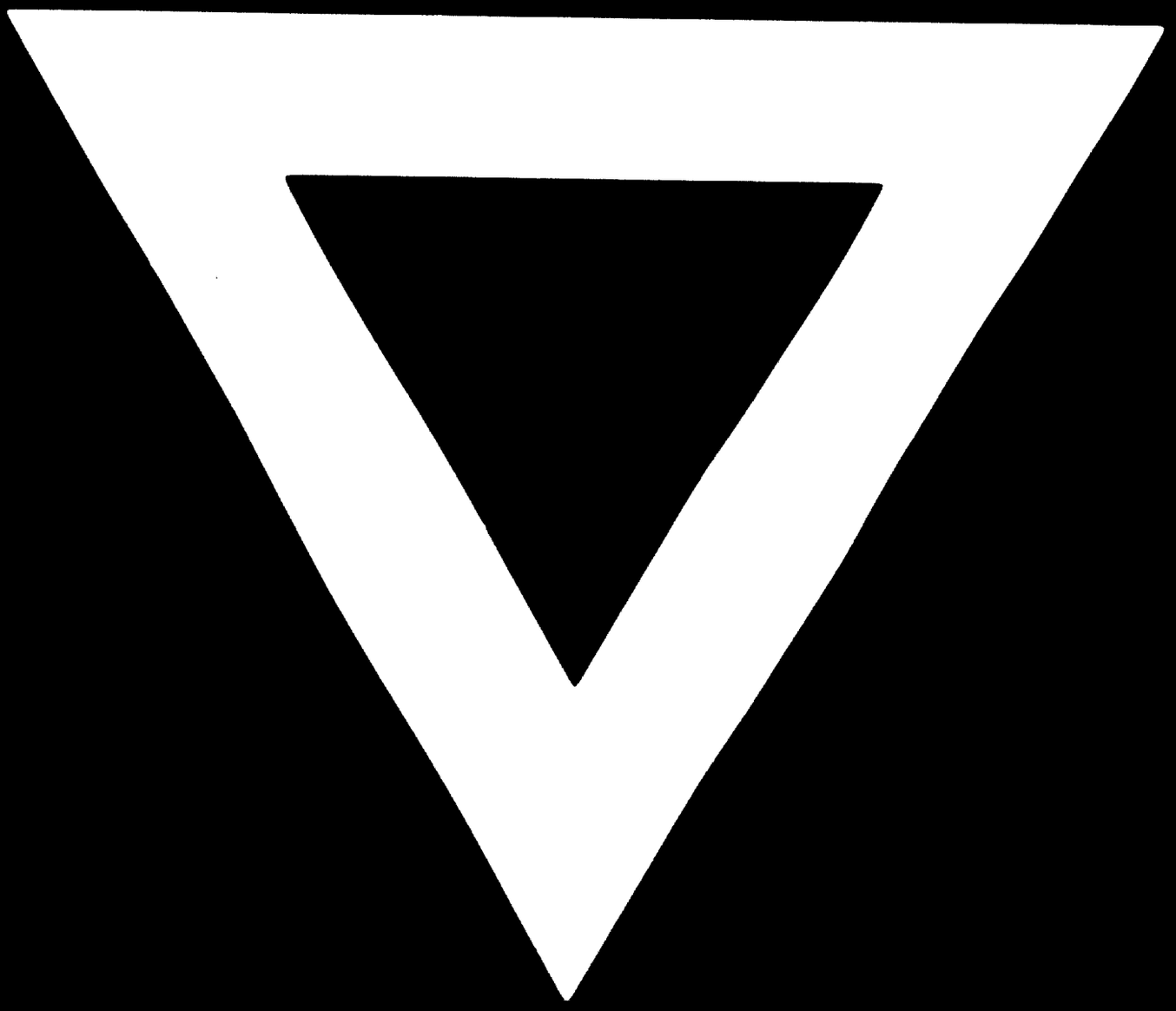

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