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Technological Capability in Oil Refining in Sierra Leone

Augustine J. Smith

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TECHNOLOGICAL CAPABILITY IN OIL REFINING IN SIERRA LEONE

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FOREWORD

The following report presents findings of a research project carried out between 1983 and 1985 by Dr. Augustine J. Smith of Njala University College in Sierra Leone. Dr. Smith's objective was to study the acquisition of technological capability by Sierra Leoneans in the oil-refining industry. Specifically, his project was concerned with the acquisition of skills and abilities by indigenous staff of the Sierra Leone Petroleum Refining Company.

After examining the level of indigenous capability in oil refining in the Company's early years, Dr. Smith studied changes which occurred in that level subsequently, up to the time of his project. A central question here was whether these amounted to technological changes. In other words, could Sierra Leone be said to have been acquiring oil-refining capability of its own in the course of these changes?

There are, of course, no precise indicators by means of which a country's acquisition of technological capability might reliably be measured. One of the contributions this report makes lies in it search for "proxies" of such indicators and in its attempt to use them in deciding whether and to what extent Sierra Leone can be considered now to have acquired indigenous technological capability in oil refining. The report's clearest contribution may lie in the empirical data it presents, much of it as further evidence of the limited reliability of foreign investment as a medium of technology transfer.

Nevertheless, a third contribution lies in the report's recommendations concerning suitable policies that Sierra Leonean authorities might wish to consider.

I hope that researchers and decision-makers in Sierra Leone, and elsewhere in Africa, will find this report useful. I must emphasize, however, that the International Development Research Centre does not necessarily agree with the views and recommendations contained in it.

Paul Vitta
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ABBREVIATIONS

AGO	automotive gas oil
ATK	aviation turbine kerosene
BFO	bunker fuel oil
BGO	bunker gas oil
BPD	barrels per day
bpsd	barrels per stream day
CE	chief engineer
CIF	cost, insurance, and freight
DPK	domestic purpose kerosene
EA	economic adviser
FM	finance manager
FO	fuel oil
FOB	free on board
GDP	gross domestic product
GNP	gross national product
GM	general manager
GOSL	Government of Sierra Leone
gpm	gallons per minute
HRL	Haifa Refineries Limited
IDO	industrial diesel oil

IG	imperial gallon
K-W	King-Wilkinson
LDC	least developed country
LFN	lead-free naphtha
LN	leaded naphtha
LPG	liquid petroleum gas
LT	long ton
MDO	marine diesel oil
NPA	National Power Authority
NRC	National Reformation Council
OTM	operations/technical manager
PMS	premium motor spirit
PPD	pour-point depressant
psig	pounds per square inch gauge
R&D	research and development
RMS	regular motor spirit
RON	research octane number
SD	special distillate
SLL	the leone (Sierra Leone currency)
SLPRC	Sierra Leone Petroleum Refining Company Ltd.
SRG	straight-run gasoline
tc	technical change

TC	technological capability
TEL	tetraethyl lead
TNC	transnational corporation
TSA	Technical Services Agreement
TTA	technology transfer agreement

CHAPTER I
INTRODUCTION

This document investigates the accumulation of technological capability within a petroleum refining company in a Third World country, Sierra Leone. The issues studied were technology, transfer of technology, technological capability, and technical change. These issues are important because they directly affect the development of the so-called least developed countries (LDCs).

Technology, which can be defined as the specialized knowledge required for production of goods and services, or the lack of it, is believed responsible for the gap between the incomes of developed and developing nations (United Nations Conference on Trade and Development, 1972). This specialized knowledge needed for production has become mostly concentrated in a few transnational corporations (TNCs), and thus the question of transfer of technology from TNCs to LDCs has become an important development issue.

One view has been that technology could be passed on to LDCs if TNCs were allowed to operate freely in them. Moreover, it was felt that foreign capital brought by the TNCs would generate more capital, entrepreneurship, tax revenue, foreign exchange, employment, and expanded output (Lewis, 1958). This is a myth. Several recent studies show that after decades of TNC activity in Third World countries employment problems have increased and foreign exchange crises are more common, and that foreign capital usually leads to a net outflow of capital (McIntyre, 1970; UN, 1973). The transfer of technology is not automatic. The recipient country must work hard to acquire it.

As a result of a successful transfer, technological capabilities may be built up within a country. These are manifested when its nationals perform technical change. It is important to understand through the collection of empirical data the contextual factors affecting the accumulation of technological capability in each country and in each region. This study is concerned with collection of such data in the West African subregion.

The Sierra Leone Economy

Sierra Leone is a West African republic with a land area of 73 326 km^2 (27 925 square miles) and, according to a 1978 census projection, a population of 4.0 million. About 80% of the population lives in rural areas and is engaged in subsistence agriculture. There is also some mining and industrial activity.

The country became independent of Britain in 1961, and like many other newly independent West African countries at the time, it immediately adopted an import substitution strategy of industrialization. Industries were selected for development according to various intangible criteria such as national prestige, with no consideration given to such issues as local availability of raw materials. The high-import-content industries developed in the early '60s would aggravate the foreign exchange crises of the late '70s; some nonessential industries would close because of a lack of foreign exchange to import raw materials and spares.

Sierra Leone did experience a period of growth shortly after independence, with the gross domestic product (GDP) showing a growth rate of 4.3% between 1960 and 1970. This was higher than the average GDP growth rate of 3.9% for sub-Saharan Africa during the same period. The corresponding subregional inflation rate was 2.9%.

The economy slowed considerably from 1970 to 1979, with a GDP growth rate of 1.6% and an inflation rate of 11.3%. The corresponding figures for the region are 2.7% and 10.3%. Agricultural production grew at a rate of 2.3%, whereas industrial production declined by 3.8%.

In 1979 the per-person gross national product (GNP) was SLL 300, with a growth rate of 0.4% between 1970 and 1979. Each year between 1970 and 1979 the country had budget deficits, and in 1979 the public and publicly guaranteed private debt stood at SLL 360 million, with an actual debt service payment of SLL 60 million. Exports, imports, and domestic capital formation had all declined (World Bank, 1979).

Table 1 gives a summary of economic indicators for the period 1976/77 to 1980/81. The poor economic performance may be attributed to factors such as continued global recession, deterioration in agricultural production and drops in prices of some local exports, mounting energy costs, and slow growth in industrialized countries resulting in a reduced market for Sierra Leone's exports. There was also fiscal mismanagement and corruption.

In more recent years, even the basic infrastructure seems to be disintegrating. The railway was dismantled in 1975 and since then the roads have been grossly overused and very poorly maintained. Power disruptions are common even in the capital because of shortages of fuel oil caused by a scarcity of foreign exchange. That scarcity also means reduced performance in other industries that cannot import vital raw materials. The main cause of this shortage is reduced exports from the agricultural and mining sectors; more and more exportable goods are being smuggled into neighbouring countries in exchange for hard currency.

Table 1. Some indicators of the Sierra Leone economy.

Indicators	1976/77	1977/78	1978/79	1979/80	1980/81
GNP at factor cost (current prices, SLL million)	656.0	733.3	891.8	1018.4	1150.7
GDP at factor cost (current prices, SLL million)	667.2	750.3	932.4	1062.9	1173.6
GDP at factor cost (1972/73 prices, SLL million)	378.3	379.1	401.7	418.0	434.3
Per-person national income (SLL)	209.65	228.25	266.8	295.9	330.1
Per-person national income (% change over previous year)	-	8.87	16.89	10.91	11.56
Gross domestic capital formation (current prices, SLL million)	97.8	96.1	138.1	187.3	246.7
Gross domestic capital formation (constant prices, SLL million)	45.6	48.4	55.3	70.9	85.9

In recent years the national currency has been grossly overvalued. Even after two recent devaluations, from SLL 2.50 per US$ 1 to SLL 6.00 per US$ 1 in February 1985, and from SLL 1.25 to SLL 2.50 per US$1 19 months earlier, the US dollar is still worth two times its official value on the the illicit market. (This document was completed in January 1986. In May 1986 the leone was floated against international currencies, and at the time of this revision in January 1987 the exchange rate had changed to SLL 50 per US$ 1.)

Science and Technology Policy in Sierra Leone

Like most other LDCs, Sierra Leone undertook industrial development without an explicit science and technology policy. LDCs felt that import substitution with direct foreign investment was an appropriate industrialization policy and that sooner or later it would lead to an automatic transfer of capital, management skills, and technical knowledge. It is obvious that such transfers never took place in Sierra Leone. In fact, it is now widely accepted that any effective transfer of technology requires a deliberate policy intervention on the part of the recipient LDC. Such a policy must compare various technologies and select appropriate one(s) for transfer, and monitor the effectiveness of the transfer as well as the assimilation and adaptation of the adopted technology. Realization of the significance of this in Sierra Leone has led to the establishment of a National Commission of Science and Technology. One immediate task of such a body is to coordinate (centralize) various science and technology activities in the country. At present, various ministries regulate different aspects of industry, and since there is little consultation among them there is much duplication of effort, resulting in wastage and inefficiency.

Thus, although the Ministry of Trade and Industry has overall responsibility for the Sierra Leone Petroleum Refining Company (SLPRC), the board chairman is the minister of finance and contracts are maintained by the Ministry of Justice. Each of the above ministries has its own mandate and there is little consultation.

The Sierra Leone Petroleum Refining Company

The Sierra Leone oil refinery was opened in 1970 as a joint venture between the government of Sierra Leone (GOSL) and subsidiaries of several transnational oil companies: BP, Mobil, Texaco, Shell, and Agip. The firm is owned and operated by the SLPRC in which GOSL has a 50% interest; the remaining 50% is held in various amounts by the subsidiaries. BP provides technical advice to SLPRC.

The refinery can process 450 000 t of crude oil per year, but it processes only 220 000 t. The refined products include premium motor spirit, domestic purpose kerosene, aviation turbine kerosene, automotive gas oil, bunker gas oil, fuel oil, bunker fuel oil, lead-free naphtha, liquid petroleum gas, marine diesel oil, and special distillate.

The refinery has 138 established positions, all held by Sierra Leoneans. There seems to be some _a priori_ evidence that much technological capability has been accumulated within the firm. The purpose of this study was to examine these indigenous capabilities and the processes by which they have been developed.

Objectives of the Study

The main concerns of this study were to examine the technological capabilities within SLPRC and to determine the extent to which these capabilities were caused by the transfer of technology from the oil TNCs. Also examined were the constraints affecting the relationship between TNCs and Sierra Leone so that specific aspects of this complex relationship, which resulted in the apparent success of the oil refinery, will be better understood. The specific objectives were:

- To determine the nature and extent of technological capabilities within the Sierra Leone oil refinery by looking for static and dynamic capabilities;
- To determine the mechanisms by which these capabilities were accumulated within the firm;
- To determine the extent to which increasing technological capabilities are reflected in increased innovation and technical change introduced by Sierra Leonean staff; and
- To identify the internal and external constraints on the firm, such as government policies, TNC control, and management contracts.

Outline of the Report

In Chapter II all relevant terms, concepts, and issues for this study are discussed, and theoretical and analytical frameworks are set for discussion of the findings. The method of investigation is discussed in Chapter III.

Presentation and analysis of data begin in Chapter IV with a review of refinery history; in Chapter V major contracts are discussed.

The technology of oil refining is studied in Chapter VI, with some introductory material on general oil refining technologies being presented. The specific situation of SLPRC is also discussed, with particular reference to the equipment and facilities available, organization of the work force, and a review of the overall skill situation.

Chapter VII deals with the performance of the company in terms of input/output data. The important issue of technical change and the existence of a technological capability at SLPRC is taken up in Chapter VIII. Chapter IX contains a summary and policy recommendations.

CHAPTER II
THEORETICAL AND ANALYTICAL FRAMEWORK

Definition of Terms

The terms used in this study will be defined and discussed in this chapter to provide a theoretical and analytical background for this report.

Technology will be defined as the specialized knowledge used in the production of goods and services. It is the sum total of the methods and techniques required for the production, distribution, and consumption of goods and services. Technology can be embodied in a person or in a piece of equipment. Girvan (1983) distinguishes three types: production, organization, and consumption technologies.

Transfer of technology refers to the imparting of knowledge from a donor to a recipient. The transfer is successful if the recipient gains control of the technology and can not only use it, but adapt it to his or her advantage. In general, transfer occurs via a TNC.

Several studies have demonstrated that in Third World countries TNCs transfer only static technologies, those that enable their possessor to carry out routine jobs in a fixed manner, using fixed equipment. Recipients of static technology do not generally have the skills for innovation and invention. TNCs rarely transfer dynamic technologies, those based on scientific principles that enable their possessor to improve on or modify the technologies (Arthur, 1978; Farrell, 1979; Bardouille, 1979; Girvan, 1979; Oddle, 1979). Recipients of dynamic technologies can innovate and invent.

A successful transfer of technology requires a basic population of educated people to receive it, the legal and administrative framework to ensure its assimilation, and a well-defined industrialization policy. Stages at which the transfer can occur include project identification, feasibility studies, design of process and equipment, detail engineering, choice of suppliers of materials and machinery, installation of plant and equipment, and start-up and operation of the plant (Barrio and Parisca, 1983). In most cases, when there are no specific policies, nationals of a recipient country are involved only in the final activity -- operation. All initial high-technology activities are performed by the TNC, so in the end only static technologies are transferred.

Vaistos (1975) refers to the transfer of technology as commercialization of technology in order to emphasize that technology is marketed by TNCs, just like other commodities. The technology market is completely dominated by the TNCs, which invariably impose a large number of restrictive and monopolistic practices on the LDCs to ensure a very high price. This is the reason Maxwell (1973) writes of "the traffic in technology." The restrictive practices are to ensure that the transfer is never complete and that the TNCs hang on to the core of the technology, allowing the recipient access only to the techniques. Even the techniques are not really transferred, because there are further restrictions on their use at the end of the contractual arrangement. Hence Oddle (1979) introduces the term technology leasing.

According to Girvan (1981), technological capability can be defined as the ability to harness reason and scientific knowledge to solve the particular problems of a specific society. This involves the ability:

- To identify problems;
- To identify the most relevant technology for solving the problems;
- To acquire that technology under the best possible terms;

- To assimilate that technology;
- To modify and adapt it as necessary to suit the local situation; and
- To create innovations internally and to commercialize these innovations.

Girvan (1981) also suggests that technological capability can exist at the level of the firm, industry, or nation. It can thus be seen that technological capability embraces acquisition of foreign technology, its assimilation and utilization, and finally the development of an indigenous science and technology.

Four main resource components of technological capability have been identified by Bell (1977):

- People with the skills to carry out functions;
- Technical knowledge for skilled workers to draw upon in carrying out their various functions;
- Tools and instruments for carrying out the functions; and
- Institutions to provide a framework for accumulating and deploying the stocks of skilled workers, technical knowledge, and instruments.

Technical change for this study is defined as by Hollander. Thus, technical change includes:

> methods used for the first time by a plant, or modifications of methods, regardless of the source of the underlying technology and regardless of whether from the point of view of the entire industry, the whole nation, or the whole world, the methods are imitative or not.

The great value of this definition, as pointed out by Maxwell (1976), is that it is very inclusive. Changes in plant organization, shifts to new labour practices, changes in specifications of products, or diversification into new product lines can all qualify as technical changes. The definition is no longer restricted to changes that reduce the unit cost of production.

Changes involving the repetition of a procedure are not regarded as technical change; Maxwell (1976) calls them scale-multiplying changes.

The fact that modifications and innovations or technical changes can have considerable economic payoffs in cheapening the cost of production and thereby improving yield per unit cost is well established. For example, in studies by both Maxwell (1976) and Dahlman (1978), personnel in Latin American steel plants resorted to technical change aimed at reducing unit cost or stretching the capability of the plant in response to pressures of market demand or local supply deficiencies.

Technical change is inevitably a product of learning by doing and accumulation of a technological capability. In this study technical change is regarded as the key to technological capability accumulation and to learning.

The approach adopted in this study is that learning by doing leads to technical change. The basic empirical evidence supporting this approach is that the unit production cost of many products declines as production experience increases. Originally, Hirsch (1956) was concerned with unit labour costs, but later studies extended the relationship between accumulation of production experience and reduction of cost to include the full range of production costs. The costs appear to decline by 20% to 30% each time total production experience doubles because production experience leads to greater efficiency.

Although some learning takes place as a by-product of normal production, it seems some projects should be devoted to the acquisition of relevant knowledge. This is referred to as learning by spending. Katz (1976) cites as an example a firm that sets aside some of its earnings for activities aimed at producing minor technical change, while the basic technology remains the same. It should be noted that learning can occur during preinvestment construction as well as in major modifications of plant technology. The former includes learning resulting from the selection of technology, construction, training of staff, the start-up, and bringing the system up to design level.

According to Hirschman (1967), another approach to learning, which seems relevant here, is crisis-induced learning. It suggests all plants experience a crisis, during which their existence may be threatened. The problems may include supply difficulties, demand that is severely inadequate or excessive, financial uncertainty, and political interference. The theory suggests that such crises bring about accelerated learning, during which corrective measures are implemented and the firm is guided away from danger.

How the Issues Relate to this Study

A major outcome of this study should be a set of technology policy recommendations. A technology policy should guide national development toward a technological capability and technological self-reliance. Girvan (1983) identifies the main problem of technology and underdevelopment as the weakness of indigenous science and technology and their inability to harness local natural resources for production and satisfaction of human needs. He suggests that the most important goals of a technology policy should be the development of an indigenous technological capability.

Fransman (1984) thinks technological capability can exist at various stages:

- The capability to search for alternative technologies and to select the most appropriate;

- The capability to use the technology successfully;
- The capability to adapt the technology to local conditions;
- The capability to develop the technology further through innovation and technical change; and
- The capability to conduct systematic research for more important innovations -- to carry out research and development.

In other words, technical change is indicative of well-developed capabilities. In this study technical change is used as a measure of technological capability.

The initial source of technology for LDCs is usually TNCs, through "commercialization" or "leasing" of technology. Importation of developed-country technology in unmodified form invariably leads to an increase in the social and economic problems of LDCs and never to a self-sustaining development (Cooper, 1973; Steward, 1977; Fransman, 1984). Care must be taken in importation to separate the technology into its core and peripheral components and to acquire peripheral technologies locally when possible. This study is concerned with the transfer of technology from a TNC to an LDC, vis-a-vis the factors favouring a successful transfer or hindering assimilation and adaptation of the imported technology.

CHAPTER III
METHODOLOGY

This is a case study of technological capability accumulation in a Third World country. The SLPRC was selected for the study after a success story was outlined at a workshop for West African science and technology policy researchers in Monrovia, Liberia in 1982. A boiler at the refinery broke down, and management wanted to hire an expatriate boiler expert. However, the national maintenance engineering team decided to repair the boiler using facilities at the local railway workshop. The repaired boiler, it seems, performed even better than before. The story clearly indicated the existence of some local technological capability at SLPRC, hence its selection for this study.

Data Acquisition

Data were collected on three aspects of the refinery -- the history, technological characteristics, and performance. The approach used was similar to that of Farrell (1979), but this study has placed much more emphasis on quantitative data collection and analysis. The research team used a combination of direct observation, interview techniques, archival research, and questionnaire methods of data collection.

The research team visited the refinery site for direct observation of the plant and its personnel. Much information was collected on the process, the various components of the plant, and the functional organization of personnel. From these initial visits a list of personnel to interview was drawn up that included all senior personnel and representatives from each group of workers. For example, only one of the four groups of shift workers was interviewed. Transcripts of the interviews were included in the first report (Smith 1984) and information from them is used throughout this report.

As part of the preliminary exercises the author observed the 1983 annual overhaul, which turned out to be a very valuable learning experience.

Concurrent with its observations and interviews, the research team also studied files, reports, memoranda, newspaper articles, statistics, and other sources of information about the refinery. The main sources of data were the Ministry of Trade and Industry, which has overall responsibility for SLPRC; the Ministry of Development and Economic Planning, which collects periodic industrial statistics; the Bank of Sierra Leone, which deals with all the foreign-exchange transactions in Sierra Leone; and the Central Statistics Office and the Statistics Division of the Sierra Leone Ports Authority, both of which collect import/export trade statistics.

Following these exercises, the research team then studied company, annual, and monthly engineering reports. The object was to identify technical changes that had occurred at the refinery and their causes and consequences. The research team interviewed senior and long-serving staff members about their recollections of technical changes. A detailed questionnaire was distributed to management and senior employees.

Government representatives on the SLPRC board were also interviewed about government policy regarding the refinery and its efforts to ensure implementation of its policies on oil refining.

As project leader, the author then visited Caracas, Venezuela, where the oil industry, including the exploration, production, transportation, refining, and petrochemical sectors, was nationalized some 10 years ago. Ten interviews were held with leaders of the national oil corporation (PDVSA) about deliberate efforts to ensure the transfer and assimilation of dynamic technology. The results of these interviews have been submitted to IDRC as a separate report.

Interviews were also held in London with officers of BP International and Shell who have been connected with the refinery in order to discuss the SLPRC with experts who had worked at the refinery as past general managers or technical advisers. Board members were also interviewed. Questions posed at BP included ones about the methods for selecting general managers, technical advisers, and contractors for SLPRC, the attitude of BP toward the Technical Services Agreement, and about the skills and technological capabilities at SLPRC.

At Shell, the relationship of the oil company directors with GOSL directors and the SLPRC problems from the debt for crude oil were the major topics. The London interviews were far less fruitful than the Venezuelan ones. The people interviewed spoke only in general terms; no information specific to SLPRC could be obtained. It seems that the only concern of these companies was that they should not be blamed in a project report for any problems at SLPRC.

About the Data Collected

The reasons for collecting particular kinds of data deserve mention to provide an overall picture of the methodology.

Archival data on the history of the refinery were collected in an effort to determine the extent that the SLPRC's preinvestment and investment phases led to learning opportunities during the operating phase.

Considerations leading to the choice of technology and the refinery's management arrangement were also studied.

The principal and technical services agreements were also studied to determine the extent to which training of local personnel for senior technical and management positions was a factor in negotiations. Some restrictive clauses that prevent effective transfer of technology were also identified.

An attempt to establish the basic mix of technology required to convert crude oil to refined petroleum products was made through a search of technical literature. This breakdown of skills was compared with a company breakdown of the essential functions at SLPRC. Most holders of important positions, including engineers, accountants, technicians, and scientists, were interviewed. This exploratory exercise attempted to determine the nature of the duties and the ability of Sierra Leoneans to perform the essential functions.

Annual reports, audited and unaudited accounts, minutes of board meetings, and other documents related to the refinery were collected, as were import/export data. The data have been analyzed in an effort to determine the extent to which technical change occurred and the refinery's ability to solve its major problems without relying on outside expertise. Engineering reports were used to identify some technical changes.

Data collection was slow because much of the available data were considered sensitive, and access was restricted.

CHAPTER IV

A BRIEF HISTORY OF THE REFINERY

The idea of operating an oil refinery in Sierra Leone dates to 1962, when Shell, London, offered to build and operate a refinery for UK£ 1.4 million to £ 1.5 million or SLL 2.8 million to SLL 3.0 million. However, Shell and the government could not reach an agreement, and negotiations broke down.

In 1964, Haifa Refineries Limited (HRL), a government-owned Israeli company, offered to help GOSL build a refinery that would be owned and operated by a limited liability company incorporated in Sierra Leone and managed by HRL. The offer included a cash loan of UK£ 400 000, or up to 25% of the construction cost, as down payment for equipment and machinery.

HRL representatives came to Freetown in March 1965 for negotiations with GOSL and it was agreed that:

- The HRL loan would be repaid from the earnings of the refinery, with interest payments starting 6 months after completion and repayment of the principal 12 months after completion; and
- The construction would be financed by suppliers' credit.

As a result of these negotiations, three agreements were signed:

The premanagement agreement covered the activities and responsibilities of HRL during the preinvestment and investment stages of the refinery. HRL was to issue international bids for machinery and equipment, accept tenders, check designs and flow sheets, supervise materials and equipment supplies, supervise construction, check compliance with timetables, and check bills and accounts of contractors and suppliers. GOSL would help HRL by issuing entry and residence visas for HRL personnel and their families, exempting them from Sierra Leone taxes, allowing repatriation of their emoluments in US dollars, allowing duty-free importation and exportation of all required apparatus, equipment, and furniture, and paying HRL a fee for its services. Disputes would be settled at the international court in the Hague, the Netherlands.

Under the management contract, HRL was to manage the refinery once it was completed. The refinery would be owned by a limited liability company incorporated in Sierra Leone. The powers of the managers were outlined. GOSL was to provide the site and land title, electrical power, fresh water, licences, and all other things needed to run the refinery efficiently. GOSL was also obliged to construct the Kissy Jetty and make it available to the refinery company and to maintain essential harbour services, including adequate pilotage and customs facilities. The refinery company was to be granted development company status and to enjoy maximum benefits under the Development Company Act.

Under the loan agreement, HRL was to lend GOSL up to US$ 1.2 million, but not more than 25% of the total cost of construction. Repayment would be in 14 equal semiannual installments starting 12 months after completion. The loan carried an interest of 6% before the completion of construction, and 7% after. The loan, which would be taken over by the refinery company, was covered by promissory notes guaranteed by GOSL.

With these agreements signed, HRL invited bids from 12 international companies in May 1965. Four bids were submitted and rejected because of unacceptable financing methods. However, a design submitted by the Litwin Engineering Company was deemed most appropriate, so HRL invited Nissho, a Japanese construction company, to tender using that design. Eventually Nissho offered to construct the refinery at a cost of US $5.46 million, and in April 1966 Nissho and GOSL signed a contract.

Twenty-five percent of the cost was provided by the loan agreement with HRL and 75% by Nissho, through a loan agreement. Nine promissory notes (annual payments) were issued and guaranteed by GOSL. The contract also included technical specifications, and it provided for examination of work before covering up and inspection and testing during manufacture. Again, GOSL would provide labour, electricity, fuel, and water free of charge. The contractor was also allowed to hire subcontractors without prior consent of GOSL, and all equipment and other items were to be purchased tax tree.

At this time HRL assured GOSL that:

- The value of the refinery products would not at any time exceed the cost, insurance, and freight (CIF) value of similar imported products; and
- that GOSL would not at any time be expected to make funds available to operate the refinery.

In June 1966, GOSL transferred US$ 40 9800 to Japan as the initial repayment of the Nissho loan.

Construction started in November 1966 and by the end of February 1967 the progress report prepared by HRL claimed the following amounts of work were completed:

- Process engineering, 97%;
- Civil engineering, 85%;
- Mechanical engineering, 55%;
- Electrical engineering, 60%; and
- Instrument engineering, 80%.

At this stage the civilian government was deposed by the National Reformation Council (NRC), a military junta, and the NRC chairman personally took charge of the refinery project. After some investigation the economic adviser to the NRC made recommendations, and it was decreed that:

- The management fees for HRL be changed from 2% of turnover to a fixed US$50 000 per annum, plus 10% of profits after deduction of operational costs and depreciation;
- HRL would raise SLL 10 000 of the estimated SLL 16 800 needed to train refinery operators. Thus HRL raised SLL 5000 and GOSL SLL16 189 for training 80 students locally. Seventy-three completed successfully a 6-month course at the technical institute. Twelve of the 73 were selected for further training in Haifa. The remaining 61 were supposed to be employed at the refinery, but construction was not yet finished. Unsuccessful attempts were made to place these students in other industries. Eventually they were asked to wait and the further training in Israel was deferred;
- HRL engineers determine whether the Kissy Jetty would be operational for the next 2 or 3 years. (They confirmed that it would be operational for at least 2 more years);
- Registration of the refinery company be deferred, since construction was not yet finished; and
- An independent firm of engineers be selected to carry out a feasibility study. (In November 1967 the King-Wilkinson Company K-W was selected.)

That report was submitted in February 1968, and highlighted several technical and financial shortcomings of the refinery project. For example, it was noted that the absence of a catalytic reformer would mean that expensive blending materials would need to be imported regularly in order to raise the research octane number of gasoline produced; that GOSL needed to provide US $850 000 for crude oil, chemicals, engineering spares, wages, and salaries before start-up; that the loan repayment scheme, based on irrevocable letters of credit due on fixed dates so that the total cost of construction was to be paid in 10 years, would be an unrealistic financial burden on the refinery company; and that the company would need GOSL subsidization in order to maintain its liquidity.

King-Wilkinson suggested that the company's capital structure be revised so as to provide the required start-up capital and to ease the loan-repayment burden. The engineers suggested that a refinery company jointly owned by GOSL (50%) and the oil marketing companies operating in Sierra Leone (50%) be formed, instead of a company wholly owned by GOSL. The suggested equity capital of the new company would be US$ 2 million; GOSL could insist on the right to subscribe later. It was also suggested that the promissory notes to HRL and Nissho be canceled and replaced by a long-term loan of US$ 5 million, payable in 15 years.

In March 1968, GOSL decided to accept the option of a refinery jointly owned by GOSL and the oil companies, and HRL was informed of the policy change. HRL didn't object. In fact, the company urged GOSL to speed up negotiations for the formation of the joint company, because construction was expected to be complete in September 1968. GOSL decided that two officials of the Ministry of Trade and Industry would go to London 5 May 1968 for negotiations with the oil companies.

While these preparations were going on there was yet another change of government, on 26 April 1968. The new civilian minister of trade and industry became immediately preoccupied with the refinery project and in May 1968 he recommended that cabinet adopt the K-W recommendations, but that the government not pay cash for its 50% share of the new company. Rather, GOSL's contribution would be limited to the government's expenditure thus far.

At this stage, the government's main concern was to relieve itself of "financial burden undertaken by the former civilian government." In fact, because of the K-W report the activities of HRL became suspect. A letter was sent to HRL in July 1968 informing the company that GOSL would stop honouring promissory notes. As well, negotiations with the oil companies were to be held in Freetown rather than London. Cabinet formed a high-level ministerial committee to look into the project. On the question of HRL activities, it noted that HRL had recommended the appointment of Litwin International as consultant. This was approved by GOSL, but later HRL had appointed itself as consultant, had drawn up and negotiated bids, and invited Litwin to bid without first getting GOSL to revoke the Litwin appointment as consultant.

Thus HRL was guilty of:

- Not obtaining GOSL cancellation of Litwin's appointment as consultant before appointing itself, contrary to the premanagement agreement; and
- Knowing of the appointment of Litwin, and also asking the company to bid.

HRL had also recommended that Badger (the Netherlands) tender, but the company refused. Later Badger formed the firm of King-Wilkinson, which was requested for the independent feasibility study of the project. There is also evidence that between June and November 1967 HRL was in contact with Shell (London) about financing King-Wilkinson for the feasibility study.

In this connection, the committee found that the role of economic adviser (EA) was of concern. The following is the sequence of events leading to the appointment of K-W:

- EA consulted the World Bank (June 1967) about engineers for the study;

- The World Bank recommended Badger, of Cambridge, Massachusetts;
- EA confirmed interest in Badger, and wrote to that company (August 1967);
- Badger indicated willingness to do a study;
- Shell London invited EA to lunch to discuss the method of financing of a study (September 1967);
- EA informed Shell (23 November 1967) of the GOSL decision to carry out independent study;
- 15 November 1967, Shell informed EA that HRL had been contacted in connection with financing study;
- HRL endorsed Shell's proposals for financing study and expressed willingness to discuss proposals for a change in management and ownership of the refinery company; and
- EA informed the Ministry of Development that K-W had been recommended to him by Badger, which had created this firm of engineers especially for the feasibility study.

Thus, EA seems to have had knowledge of important facts that were withheld from GOSL. These are:

- That HRL was in contact with Shell as early as April 1967, with a view to withdrawing from arrangements with GOSL;
- That K-W was an engineering firm working for Badger, a company known to HRL, and that this firm was formed just to evaluate the refinery project; and
- That HRL had on many occasions inflated prices and cost of products to produce favourable and positive cash flows.

The committee recommended that GOSL seek legal advice, and referred the matter to the then attorney general.

The Ministry of Trade and Industry drew up guidelines for negotiations with oil companies:

- Equity capital of the new company should be US$ 3 million, or SLL 2.5 million to ensure liquidity;
- GOSL and the oil companies would each own 50%, with chairmanship provided by GOSL;
- Payment of the GOSL contribution would be through capitalization of the amount already spent, together with value of the site and other items; the rest of the payment should be through royalties due GOSL;
- How the refinery would be managed;
- How many Sierra Leoneans would be employed at all levels, especially the 73 students trained at the technical institute at GOSL expense;
- The price of products would not exceed the CIF value of imported petroleum products;
- There would be an excise tax on refinery products equivalent to the existing import duty on similar imported products so that there would be no loss of revenue;
- Liabilities, such as the promissory notes to HRL and Nissho, would be transferred to the refinery company;
- There would be a timetable for takeover of the refinery; and
- What the terms would be for the development certificate of the refinery company.

Construction was eventually completed at the end of 1968, and the plant was commissioned in January 1969 by BP Trading, London, which brought in a team of 42 expatriates under the terms of a Technical Service Agreement signed in May 1969. The BP team was to start refinery operations and to recruit and train Sierra Leoneans, who would eventually take over.

The Imperfections in Negotiations

GOSL did not undertake a feasibility study after HRL suggested that it would build a refinery in Sierra Leone. Rather, GOSL relied completely on HRL promises that the refined products would not cost more than imported ones, that the refinery would be able to pay for itself, and that GOSL would not have to spend any more money in that respect.

Both HRL and the EA seem to have had interests that did not coincide with those of GOSL.

The request for a feasibility study by King-Wilkinson, and the change in proposed HRL fees from 2% of total turnover to 10% of the profits were two very positive steps taken by GOSL.

The K-W study may have been financed by Shell (London), and this may have considerably influenced the feasibility report. In particular, the recommendation that the oil TNCs become partners with GOSL in forming the new refinery company was not necessarily the best one. It appears that a truly independent study would have recommended other possibilities, such as a long-term loan from the World Bank, to pay off the short-term loan commitments of GOSL and to start a refinery wholly owned by GOSL.

GOSL did show some concern for training, even though this was restricted to the training of 80 operators at the Sierra Leone Technical Institute. A similar plan for engineers and senior oil experts should have been demanded. During negotiations there was some discussion about training Sierra Leoneans to take over the refinery. However, no money was set aside for this and no firm timetables were established. Thus, training was left entirely to the wishes of the oil TNCs.

CHAPTER V
THE TECHNOLOGY TRANSFER AGREEMENTS

The activities and functions of SLPRC are governed by two main agreements: The Sierra Leone Petroleum Refinery Company Limited Agreement, approved by the Sierra Leone parliament in 1972 and called the principal agreement, and the Technical Services Agreement, first signed in 1969. These provide the macroenvironment within which technology is transferred from oil companies to SLPRC. These need close examination if one is to determine whether GOSL made provisions to ensure a transfer of technology and a buildup of some technological capability in oil refining.

The Principal Agreement

The principal agreement, which was ratified by an act of parliament, formally established SLPRC. It is a contract between GOSL and, initially, five oil TNCs operating in Sierra Leone. The authorized equity capital of the company was SLL 2.28 million distributed as follows: GOSL, 50%; BP, 6.9%; Shell, 17.7%; Texaco, 10.8%; Mobil, 11.3%; and Agip, 3.3%. When Agip folded in 1974, BP acquired all its shares. BP has since sold all of its shares to Precious Minerals Mining Company, a local company.

The agreement:

- Limits refinery activities to processing crude oil purchased from the oil companies;
- Stipulates that the refinery be operated profitably, in particular that dividends be paid each year at a rate providing not less than a

15% return on the full equity capital during the first 15 years;

- Defines the equity-share capital structure of the company;
- Limits the sale of GOSL shares to citizens of Sierra Leone and oil company shares to oil company affiliates;
- Requires that oil company shares be sold only to oil companies, and not to GOSL;
- Requires GOSL to sell the refinery site and machinery to SLPRC;
- Requires SLPRC to take over GOSL debts for the construction of the refinery and to refund to GOSL amounts already spent in connection with the refinery project;
- Requires the refinery to purchase crude oil and other necessary feedstock at competitive prices from the oil company participants and to process these to meet the needs of Sierra Leone's internal market only;
- Gives the oil companies the sole right and obligation to supply suitable crude oil and feedstock at commercially competitive prices from any sources they choose, having regard to quality and quantity, and including appropriate freight rates, insurance, port dues, and wharfage;
- Allows GOSL to supply a maximum of 50% of the crude oil needed by SLPRC if a suitable and competitive crude-oil source is discovered in Sierra Leone;
- Gives the right to purchase all products derived from domestic processing to the oil companies and their affiliates;
- Gives the oil companies the sole right to import products to cover shortages caused by insufficient local processing;
- Requires SLPRC to determine product prices by first estimating its yearly revenue requirements and, subject to the recommendations of an

advisory committee, adjusting its product prices to eliminate any shortfalls. Prices could also be increased following increases in crude oil prices or substantial increases in taxation;

- Gives the oil companies the sole right to purchase products in excess of domestic market requirements;
- Allows participants to utilize any excess capacity to process their own crude oil for export, after the domestic market had been satisfied;
- Allows oil companies to transport crude oil or feedstock or products in any vessels they choose;
- Requires the refinery to operate under a technical services agreement, the first 3 years with BP, and thereafter with any reputable oil company;
- Defines the corporate structure of the company such that each share carries one vote at general meetings. The board shall have five GOSL directors, who together hold 50% of the votes, and each oil company one director. The general manager is a nonvoting member of the board, and all major matters require a resolution carried by votes representing 80% of the shares;
- Requires the company to make efforts to employ suitably qualified Sierra Leoneans to the maximum possible;
- Gives the refining company the status of a development company, with all the benefits stipulated under the Development Act of 1960;
- Requires GOSL to authorize without undue delay the transfer of all foreign-exchange requirements for the purchase of crude oil and feedstock, and also the remittance of dividends, loan and loan interest repayments, services fees, capital distributions, and proceeds from sales of refining company shares;

- Exempts SLPRC from payment of duties on crude oil and feedstocks and on all equipment supplies for operation and maintenance of the refinery and for implementation of capital projects. Excise duty on products sold locally would be paid only after the products are sold;
- Requires GOSL to ensure Kissy Jetty is suitably maintained for receipt of crude oil; and
- Stipulates that all disputes shall be arbitrated in Geneva and the laws of Sierra Leone and rules of international law are applicable.

Training

The only clause of the principal agreement that deals with the transfer of technology states:

> The refinery company will employ suitably qualified Sierra Leone nationals to the maximum extent possible and with the advice and assistance of the technical advisers will implement training programmes (including, wherever possible, training in overseas centres) designed to phase out expatriate staff as rapidly as possible.

This policy statement is weak, as it has no instruments whereby it may be implemented. No specific timetables or funding procedures for training schemes are recommended. Sierra Leoneans have replaced expatriate staff rather rapidly because of two main factors, the low technological content and limited extent of SLPRC operations, and considerations of company profitability, since a Sierra Leonean could be employed for a fraction of the cost of employing a equally qualified and experienced expatriate.

The distribution of top management personnel and junior and senior employees over the last 5 years (Table 2) shows how management positions which were all filled by expatriates in 1980 were all filled by Sierra

Leonean managers in 1985.

Table 2. Expatriate and local staff of the Sierra Leone Petroleum Refining Company Limited, 1980-85.[a]

Year	No of expatriates		Management	Senior[b] staff	Junior[c] staff
1980	3	GM (1)	3 (expatriates)	31	100
		FM (1)			
		TA (1)			
1981	2	GM (1)	2 (expatriates)	29	100
		EA (1)	3 (S. Leoneans)		
1982	2	GM (1)	2 (expatriates)	29	100
		TA (1)	3 (S. Leoneans)		
1983	2	GM (1)	2 (expatriates)	31	98
		EA (1)	3 (S. Leoneans)		
1984	1	TA (1)	4 (S. Leoneans) (GM, FM, CE, OM)	31	99
1985	1	TA (1)	4 (S. Leoneans)	31	95

[a] GM - general manager; FM - financial manager; TA - technical adviser; CE - chief engineer; EA - engineering adviser; OM - operations manager.

[b] Senior staff includes professional staff, engineers, accountants, chemists and administrators.

[c] Junior staff includes fitters, operators, fire, safety and security personnel, typists, laboratory assistants, and accounting clerks.

The idea of a Sierra Leonean general manager was suggested by GOSL. The man nominated for the position came to the refinery in 1970 with a degree in physics/chemistry from the Fourah Bay College. Since then he has held all senior positions associated with the operations department, from shift control to superintendent, operations/technical. He is therefore one of the Sierra Leoneans who is most knowledgeable about the refinery. He was first given the supernumerary position of deputy general manager in which he understudied the general manager for a year. He then undertook an intensive training course on management practices before he finally took up the general manager's job in 1984.

Profitability

Profitability has always been a main concern at SLPRC and the price-increasing mechanism of the principal agreement has been a major tool for maintaining solvency. At the end of every financial year the company reviews its revenue budget and if any shortfall is anticipated, an advisory committee is set up (two GOSL board members, two oil company board members, and the general manager) to recommend an appropriate price increase. Several options are usually proposed to the government through the SLPRC board. The oil company directors will always ensure that GOSL effects the recommended price increase.

Price increases have usually been awarded with each rise in crude oil prices. The main disadvantage of this system is that it gives the refinery little incentive for innovation. Whenever there is a cash shortfall, irrespective of whether it is caused by commercially or technically unsound practices, prices are increased. Incompetence is not penalized.

Crude Oil Supplies

The crude oil supply arrangements stipulated in the principal agreement, whereby the oil TNCs had the sole right to supply crude oil to SLPRC from sources of their choice using vessels of their choice, was bound to cause problems. In 1974, planners in the Ministry of Development and Economic Planning discovered that SLPRC was paying far too much for its crude oil. Although the cost of Kuwaiti crude oil in March 1974 was US$ 7 a barrel free on board (FOB) (Economist, 23 March 1974, p. 75), SLPRC was importing crude from Nigeria for US$ 15.20 a barrel FOB. The difference in price was too high, even though Kuwaiti crude had higher freight charges and a greater sulfur content that resulted in higher processing costs.

After an analysis that took freight, insurance, and export of excess fuel oil into account, planning officers estimated that SLPRC would save more than 43% of its crude oil costs by importing Kuwaiti instead of Nigerian oil.

When confronted, refinery management said that the type of Nigerian crude required by the refinery was not available to all suppliers, and therefore it was reasonable for SLPRC to pay marginally more. Management also tried to discourage GOSL from exploring the possibility of entering a government-to-government crude oil supply agreement with Nigeria, warning that any such arrangement was in contravention of the principal agreement.

Another reason that the supply arrangement was bound to run into problems was that SLPRC had to pay for crude oil in foreign currency, whereas it received leones for the refined products. The problem was aptly stated by the general manager, who wrote:

> What was once a profitable company has rapidly sunk down from 1979 to date (1982) into a state of insolvency due to circumstances beyond the control of management. Since 1979 Sierra Leone has been faced

> with deteriorating foreign exchange problems principally due to: world crude crisis of 1979, which lead to higher oil import bills; huge national expenditure towards the hosting of the 1980 Organization of African Unity Summit in Freetown; and reduced earnings from export commodities arising from global economic recession.
>
> The problems have had serious repercussions on the financial situation of the oil refinery to the extent that the company is now insolvent. The continuing non-availability of foreign exchange to fund the company's overseas commitments has resulted in the accumulation of a huge debt to the oil company suppliers which attracts interest, a cost which does not contribute to the yearly activities to yield revenue but increases in value, now running up to 6 to 8 million Leones per annum. The non-availability of foreign exchange also imposes constraints on crude oil availability, resulting in lower levels of activity. Therefore the company's ability to maximize its profits is limited (Koroma, 1982).

SLPRC's indebtedness to suppliers of crude oil and platformate totaled more than US$ 45 million by 30 September 1982. The oil companies had stopped shipping platformate in mid-1982. SLPRC responded by reducing the research octane number (RON) of premium motor spirit (PMS) from 93, which could be achieved with platformate blending, to 85, which was achieved by blending straight-run gasoline (SRG) with TEL (tetraethyl lead).

As a second step, the oil TNCs stopped all forward cargoes of crude oil. This led to serious supply disruptions, eventually causing severe product shortages. To alleviate the situation, GOSL utilized all available foreign exchange to secure crude oil or, in most cases, the most vital products that were in short supply.

Toward the end of 1982, the oil TNCs agreed to extend the debt-repayment period if GOSL would make 30 regular monthly payments of US$6 million into a special New York escrow account to cover debt, interest on debt, and advance payments for a reduced crude oil parcel size. GOSL accepted another arrangement whereby the oil TNCs agreed to pass to GOSL their right to provide crude oil for SLPRC, and GOSL would pay US$1.6 million into the New York escrow account to cover only debt and interest payments. Two such payments were made at the beginning of 1983. GOSL continued to procure crude oil for SLPRC, but it arrived irregularly. This resulted in continued product shortages, rationing, hoarding, and long queues for fuel.

The disposal of excess fuel oil is also being handled differently than the principal agreement stipulates. Because of the world trade recession, Freetown bunker oil trade has fallen off and excess fuel oil now accumulates regularly. The principal agreement required the oil TNCs to dispose of this on the bunker market, and SLPRC generally recovered very little from the sale. As the shortages continued, SLPRC arranged a swap deal with a third party: excess fuel oil (FO) would be traded for badly needed premium motor spirit (PMS). This reduced excess FO and alleviated some PMS shortages, with no foreign exchange being required. The deal was supported by both GOSL and the oil TNCs, and has been repeated several times since 1983. International spot market prices were used for the exchanges. Now, however, both GOSL and the oil TNCs want to secure excess FO for themselves; SLPRC prefers the third-party deals, so as to maximize profits.

The fact that GOSL (not SLPRC) now has to seek the foreign exchange for crude oil has led to a new attitude in the Ministry of Finance toward product price increases. In the past this ministry had reviewed SLPRC product-price-increase proposals with the aim of minimizing them. Their inclination now is to maximize the increases (keeping political expediency in mind), in an attempt to reduce heavy foreign-exchange bills for oil imports. The resulting higher product prices are expected to drive demand for oil products down. The last two increases were from SLL 3.40 to SLL 5.00 per imperial gallon (IG), and then from SLL 5.00 to SLL 8.00/IG. Both increases were greater than SLPRC had requested.

The Technical Services Agreement

The Technical Services Agreement (TSA) between SLPRC and BP International is a materials-cum-services procurement agreement that was first entered into 25 May 1969, and then renewed every 3 years (Table 3).

Table 3. Timetable for the technical services agreements.

Signature date	Commencement date	Termination date
18-02-1972	25-05-1972	24-05-1975
16-01-1975	25-05-1975	24-05-1978
28-07-1977	25-05-1978	24-05-1981[a]
18-09-1981	01-10-1981	31-12-1983[b]

[a] Extended by mutual agreement until 30-09-1981.

[b] End of initial period: agreement to be automatically renewed thereafter, subject to 12 months' notice.

- BP undertook to provide SLPRC with such technical and other advice and services including procurement of materials, as the company might reasonably require to operate and efficiently maintain the refinery, including, but not limited to, advice and services in connection with:
  - (i) operation and maintenance of the refinery;
  - (ii) operating programs, technical procedures, processes, and product qualities;
  - (iii) recruitment of personnel;
  - (iv) training;
  - (v) financial and accounting matters, insurance, industrial relations, safety, plant protection, and medical matters;
  - (vi) negotiation of contracts with third parties for goods and services other than crude oil or products;
  - (vii) formulation, assessment, execution, and operation of any proposed alteration or addition to the refinery.
- BP would act as purchasing and forwarding agent for the company for material purchases made outside Sierra Leone, including shipping, inspection, and documentation, and provision of BP's Vocabulary of Stores.
- BP could terminate the agreement in the event of either:
  - (i) SLPRC going into liquidation; or
  - (ii) the company falling behind in payments due BP under the agreement.
- For the normal technical advice and other services provided under the agreement, up to a limit of 30 work hours for any one problem, SLPRC would pay BP a fixed fee of UK£ 52 000 per annum, subject to 6-month increases. Charges for advice in excess of the limit, or for advice

in connection with alterations or additions to the refinery, would be made separately.

- For material services SLPRC would reimburse BP's costs and pay a commission of 4% of the delivered cost of the material, subject to a maximum of UK£ 5000 commission on any one order. SLPRC would pay a single fee of UK£ 5000 for BP's Vocabulary of Stores.
- Accommodation, travel, and other normal expenses incurred by personnel in servicing the agreement and also for selection and training of SLPRC personnel would be reimbursed by the refining company.
- The agreement was made subject to English law.

Appendix B-1 gives a summary of the assistance requested/provided for the first year of the current agreement, and Appendix B-2 is a list of visits by BP personnel to SLPRC and by SLPRC personnel to the United Kingdom, arranged under the TSA.

The amount spent by SLPRC on the TSA in a year (Table 4) included head office and technical and personnel services, which taken together were as high as 40% of total expenditures.

The current agreement differs from previous agreements in three ways:

- Services are restricted to the technical field and are provided at the request of SLPRC;
- Payments to BP are now provided through a current account maintained by BP on behalf of SLPRC; and
- After the initial period, the agreement remains in effect unless canceled by mutual agreement.

The TSA fails to deal effectively with the issue of training Sierra Leoneans to replace the expatriates who were initially engaged to commission and run the refinery. Under such circumstances, one expects

Table 4. Percentage breakdown of costs for SLPRC, 1971 - 83.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Operations	11.55	10.78	11.14	8.89	5.70	4.48	5.57	5.05	4.41	4.15	4.64	4.49	4.36
Additives/dyes	8.15	8.49	9.94	14.14	17.16	18.06	15.65	15.32	19.18	13.27	9.85	9.02	10.54
Power	8.83	5.32	7.29	6.94	12.10	10.24	9.99	8.13	7.22	5.68	4.50	6.69	5.61
Water	2.16	2.79	2.38	2.04	1.36	1.89	2.04	1.86	1.87	2.11	1.85	2.32	1.73
Maintenance	4.94	4.04	2.12	4.62	3.76	4.60	6.20	11.59	8.59	5.59	6.13	7.37	6.63
Laboratory	2.93	2.03	2.11	1.76	1.61	1.73	2.71	2.00	2.04	2.07	1.98	2.40	2.90
Stores	1.32	1.57	2.06	2.17	1.78	3.12	1.42	2.22	1.60	2.49	1.10	1.37	1.64
Training	0.62	1.19	1.01	0.90	0.79	0.33	0.43	0.48	1.56	1.31	0.78	1.02	0.91
Fire/safety	2.40	2.64	2.13	2.06	2.85	1.71	2.71	2.67	3.03	3.20	2.70	3.10	3.17
Refinery general	4.82	2.93	3.74	5.35	2.28	2.22	3.15	3.62	3.83	4.23	4.02	4.66	5.07
Personnel charges	12.41	7.61	7.34	5.81	8.72	5.76	6.44	5.66	8.00	7.71	7.41	8.29	7.32
Rates/insurance	8.84	4.70	5.25	4.73	3.38	3.28	4.92	5.06	5.58	6.21	6.71	7.31	5.63
Technical services	6.84	4.54	5.70	5.20	2.91	4.63	5.14	4.89	5.21	5.45	6.27	8.03	9.41
Head office	24.60	24.99	33.98	30.98	33.01	34.76	32.21	27.99	25.00	34.25	40.41	29.51	29.38
Special costs	-	13.07	-	-	-	-	-	-	-	-	-	-	-
Annual overhaul	0.00	3.29	3.79	4.42	2.59	3.28	3.15	3.47	2.87	2.27	1.64	4.40	5.71

that the technical advisers would try to maintain a large number of expatriates at the refinery. However, the number (42) of expatriates was reduced rather rapidly to only 2 at the end of 10 years, and all positions, including management ones, were filled by Sierra Leoneans after about 14 years.

It appears that company profitability is one of the main reasons for this rather sudden transformation. Because the technical advisers were also participants in a very profitable joint venture, it was in their best interest and those of the other participating oil TNCs to maintain a good relationship with the government and not to arouse any nationalistic feelings in the local population. The oil TNCs wanted to make as much profit as possible over as long a period as possible, so if SLPRC management could identify a local worker who could be employed at a fraction of the cost of an equally qualified and experienced expatriate, the local worker was hired and given on-the-job training by his expatriate counterpart.

This training was usually carried out over 6-12 months within the refinery. The newly employed Sierra Leonean would follow the expatriate as the latter carried out normal duties, allowing the Sierra Leonean to pick up the tricks of the trade. Interviews revealed that for supervisory positions in engineering, operations, or finance, the Sierra Leonean was usually a university graduate, whereas the expatriate was not.

This scheme was quite inexpensive; it did not as a rule involve overseas training. This seems to have been the way all top positions at SLPRC were filled locally, except for management positions. These required direct GOSL intervention.

It seems that the transfer of technology and the development of a technological capability were not the main concerns of GOSL during the refinery's postinvestment period. (The major agreements were drawn up after the investment stage.) Although personnel training is mentioned in passing in both major agreements, no programs for local personnel to take over refinery operations were drawn up, no funding procedures for training schemes were arranged and no local participation clauses were included in the TSA. In fact, much was left to the technical advisers and other oil company participants in the joint venture. For TNCs, company profitability and maintenance of a good image have been major considerations guiding decisions on such issues as SLPRC's huge crude oil debts, the transfer to GOSL of the right to supply crude oil to SLPRC, and the transfer of refinery management to Sierra Leoneans.

CHAPTER VI
TECHNOLOGICAL CHARACTERISTICS OF SLPRC

This chapter outlines the technological requirements of oil refineries in general and then of SLPRC in particular, as well as the essential functions of the refinery, i.e., those necessary for its continued operation. Much of the material on the general refinery comes from a BP manual, Our Industry Petroleum (BP 1977). The general refinery structure described here was found to be similar to that of refineries in the United Kingdom, Venezuela, and Sierra Leone.

Essential Functions at a General Refinery

The organization of any refinery depends to some extent on the type of refinery, the country's customs, and the personal preferences of the refinery manager. There are, however, basic aspects of refinery organization that seem to be the same for all refineries, whether big or small, or in a developing or a developed country. The success of a refinery depends ultimately on the qualities of its workers, and the integration of these qualities to obtain maximum efficiency. This section, therefore, summarizes the key personnel and the roles they play in resolving the problems involved in transforming crude oil into finished products.

The fundamental functions needed to run a general refinery are:

(a) Preparation of a refinery program for production planning and control to meet marketing requirements;

(b) Safe and efficient operation of process units, utilities, blending pumping, and dispatch facilities;
(c) Production scheduling to implement the refinery programs;
(d) Safe practices and firefighting;
(e) Development and troubleshooting;
(f) Supervision of all mechanical, electrical, and civil engineering activities;
(g) Scheduling and supervision of routine and emergency overhauls; and
(h) Administration, accounts, and personnel control under the general manager.

These functions are usually divided into four main sections under the technical superintendent: (a), (c), (e); operations superintendent: (b), (d); engineering superintendent: (f), (g); administrative superintendent: (h).

There must be a high degree of cooperation and liaison among these superintendents at all times, and also with the refinery manager, who normally meets regularly with the superintendents to discuss various programs and activities.

Nomenclature of the various functions may vary among refineries and the hierarchical structure may differ, but the functions are the same.

The refinery manager is final arbiter on the activities of all superintendents. He creates incentives and a good working climate for all personnel and evaluates the performance of senior staff. He is also concerned with refinery personnel in terms of functions, human relations, productivity, and efficiency, and is concerned with relations with local authorities, government officials, head office, and unions. He also appoints and allocates duties to all senior officers. This is a position of overall command and requires an efficient and capable individual.

A refinery must not only convert crude oil into a considerable number of salable products within rigid specifications but also be capable of receiving crude oil and dispatching products meeting these specifications. The technical superintendent and his team deal with production control (including the refinery program), blending, and stock control, and maintain master records of all stocks and movements so that the refinery input and output can be reconciled.

Refinery programming is the foundation of refinery operations. The program must be economically optimized in terms of chosen crudes to set yield patterns for all process units and blending formulation to meet final product specifications. It must also take into account dispatch programs by land and sea. The technical department is responsible for carrying out the program, and also for controlling the laboratory which is under the works chemist. The works chemist checks final quality. He certifies the products and is responsible for analytic services covering such areas as water treatment and processing problems.

The technical superintendent and his staff must cooperate in matters such as trouble-shooting and identifying bottlenecks in units by making test runs. He will also be involved in corrosion investigations and in helping other departments in exercises involving laboratory testing.

The implementation of all operations arising from the detailed programs is fulfilled by the operations superintendent and his unit. These functions may be divided into two parts -- control of the process and control of off-site operations. The latter includes control of blending components into finished products, tankage, and dispatches.

The operations superintendent is responsible for the plant's safe operation and takes any measures needed to protect it in case of fire. The fire safety officer is directly responsible to him but also has access to the manager.

He is also responsible for training new workers and periodic retraining of more experienced personnel, including the training officer, who is responsible to the operations superintendent.

Control of operations must be carried out in conjunction with the technical and engineering superintendents. This section must ensure that the requisite conditions of temperature, level, flow, and pressure are maintained in all processing units.

Engineering responsibilities are governed by two dominant factors affecting engineering aspects of the oil industry:

- Its continued growth that, by virtue of its sheer size and complexity of operation, together with demands for new and improved processes, is continually pushing design and construction beyond the limits of current practice and experience.
- In common with other industries, there is the ever-increasing need for greater efficiency, economy in operations, and improved productivity. Providing the means to carry out these operations with a high degree of reliability, while safeguarding personnel and plant and paying due regard to the overall economies of the operation, is the engineer's job.

One duty of the engineering superintendent is the scheduling of major and routine overhauls. There is also a maintenance engineer in this section who must have broad knowledge in several fields and the ability to deal with specialists.

All refinery process plants must be shut down periodically for major scheduled maintenance and inspection.

Instrumentation has become sophisticated in an attempt to improve efficiency, and the engineering department is responsible for this equipment.

The administrative and accounts sections are quite separate from the duties discussed so far, but they are important in all organizations. Administration normally begins with the refinery manager and branches out into personnel and accounts. The personnel controller is responsible for overseeing general employment and the the accounts section handles financial management.

The Refining Plant and Process

The plant and process description was as provided by the technical advisers (Jones, 1982). The SLPRC refining plant was designed to process up to 10000 barrels of Manjid crude oil per stream day. The plant consists of a crude fractionation column, gasoline [1900 barrels per day (BPD)], and kerosene (1500 BPD) stabilizing units, with merox treatment units and a liquid petroleum gas (LPG) unit (96 BPD).

The incoming crude passes through several heat exchangers and is then introduced into the flash zone of the distillation tower after being further heated to about 650°C by a fired heater.

After numerous other steps, a butane-rich LPG stream is withdrawn from tray five of the stabilizer column, cooled, caustic washed if necessary, and then routed to LPG storage.

The condensed gasoline from the stabilizer bottom is reboiled against gas oil from the distillation unit, heat exchanged with stabilizer feed, water cooled, and then sent to storage. There is a merox-sweetening unit for treating the gasoline when high-sulfur crude oil is being processed.

Liquid kerosene and gas oil withdrawn from trays 24 and 22, respectively, of the distillation tower are vacuum stripped and the stripped vapours are partly condensed and refluxed back to the column. The kerosene is cooled against crude oil, soda washed, and merox sweetened (if high-sulfur crudes are being processed) before being sent to storage. The gas oil is also cooled against crude oil and water, and then sent to storage.

The residue is stripped in the main column, then cooled against crude oil. It then receives further cooling in a cooler box and a pour-point depressant, Shellswim 5X, is added before it is stored as fuel oil.

Utilities

The utilities include fuel, electric power, steam, cooling water, process water, instruments air, and service air.

The heater and boiler use fuel gas and fuel oil refined at the plant.

Electricity is supplied by the National Power Authority. The refinery also operates a standby diesel generator, which is used to keep the plant functioning during a power failure.

An automatic package boiler produces saturated steam. The boiler feed water is softened.

A double-cell induced draught tower meets the cooling and condensing needs of the process area. Because of a buildup of restrictive internal corrosion in the pipework, chemical cleaning has been introduced, and the pH of the cooling water is now controlled by caustic injection into the tower.

Raw water coming in from the Guma Valley Authority through a 20-cm (8-inch) pipe is used for the cooling water tower's make-up water, boiler feed water, sanitary and other purposes. Treated water is available for domestic uses.

Two electrical compressors with silica gel dryers provide dry air for pneumatic control instrumentation. A third compressor provides air for air-driven tools and the laboratory.

Other facilities include a flare, an oily-water separator, a blowdown system for discarding hot and cold hydrocarbons in an emergency, a neutralizing pit for acids and alkalines, and an extensive tank farm for storage.

A flowchart of the process is given in Appendix C-1. Table 5 provides a summary of plant facilities.

Straight-run gasoline (SRG) is blended with TEL (tetraethyl lead) to produce gasoline of about 85 research octane number (RON), which is then marketed as premium motor spirit (PMS). Before the foreign-exchange crisis, the SRG was blended with imported platformate to bring it to 93 RON, and then coloured and sold as PMS.

Kerosene that is to be marketed as aviation turbine kerosene (ATK) is treated with one part per million of ASA-3 antistatic additive to attain the ATK conductivity specification. Domestic purpose kerosene and gas oil require no other additives, whereas fuel oil requires a pour-point depressant. LPG, which is stored in horizontal cylindrical tanks, is treated with ethyl mercaptan stench before it is transferred to the Shell bottling plant. Slops from the oily water separator are thoroughly drained of water and injected slowly into the crude feed. Small quantities of lead-free naphtha and white spirit are drum-filled from the process unit for sale to local industry.

Table 5. Refinery plant and facilities.

Units	Description
Processing Units	Crude oil distillation
	Gasoline stabilizer
	Gasoline merox
	Kerosene acid/soda/merox
	Liquid petroleum gas
	Tetraethyl lead blending
	Integral control room
Utilities	Package boiler (Marshall CB250)
	Emergency generator (Western engines)
	Fresh water cooling distribution system with tower
	Compressed instrument/service air system
	Diesel-driven fire pumps/hydrants/foam production
	Oily water separator
Tankage	1 x 20000 m^3 Crude oil (floating roof (FR))
	1 x 10000 m^3 Crude oil (FR)
	3 x 2000 m^3 Platformate (FR); fuel oil (2)
	8 x 1000 m^3 Gasoline (3 FR); kerosene (2); gas oil (3)
	2 x 150 m^3 Slops
	2 x 32 m^3 Liquid petroleum gas

Table 5 continued.

Units	Description
	Mobil leased tankage 1 x 15000 m^3 Crude oil 1 x 6000 m^3 Crude oil
<u>Buildings</u>	Main office Laboratory Fire station/medical centre Stores Workshops Bundle cleaning Generator/switch gear housing Canteen

Source: SLPRC

Crude oil and some refined products are imported via the Kissy Jetty adjacent to the refinery. The jetty can accommodate tankers of up to 35000-t dead weight. Three flow booms, for crude/black oils, white oils, and bunker operations, are available.

The fire-fighting system at the refinery includes a fixed diesel-driven fire pump, and fire water ring mains around crude tanks, product tanks, and the processing area.

The Organization and Skills at SLPRC

The SLPRC organization chart is in Appendix A. The general manager (GM) is the chief executive, directly responsible to the board of directors. He is an additional director, but cannot vote. He is advised by a management group consisting of the finance manager/company secretary (FM), the chief engineer (CE), and the operations technical manager (OTM).

All departments report to a manager. The operations/technical departments report to the OTM, the mechanical, instrument, and electrical engineering sections to the CE, the accounts and stores sections to the FM, and the administration and security sections to the GM.

The administration department, headed by an administrative superintendent, has three sections:

- The administration section, which provides personnel and general services, such as backup to the purchasing department. Union activities are monitored and dealt with preliminarily by this section;
- The public relations and training section; and
- The medical services section.

The operations/technical department refines the crude oil and monitors its quantity and quality and the flow of products. The four subsections are:

- The laboratory section, headed by a works chemist, carries out the full range of petroleum tests;

- The operations section, headed by the operations superintendent, actually runs the plant;
- The production section, headed by the production estimator, does production planning and some market research; and
- The fire and safety department, under a fire and safety officer, is in charge of all safety operations, fire prevention and fighting, and handling of dangerous chemicals.

The chief engineer heads the engineering department. Engineering activities are supervised by a refinery maintenance engineer, supported by electrical, instrument, and mechanical engineers. This department is responsible for all maintenance and engineering services. There is a planned annual general inspection and overhaul, coordinated by a development and coordination engineer.

The finance department is responsible for maintaining proper records. The department produces a monthly set of accounts, capital and revenue budgets, and cash-flow statements that are submitted to the directors. The department operates a provident fund for employees through a board of trustees. Consumable stores, including chemicals, mechanical and electrical equipment, and spares, are stocked and issued to user departments by the stores (and purchasing) department, which is another arm of the finance department. The department is headed by the finance manager, who is also the company secretary. The chief accountant, accountant, and stores supervisor are subheads.

This breakdown of functions indicates clearly their similarity to general functions performed at a general refinery. There are slight variations resulting from the limited scope of activities at SLPRC. For example, the functions of the technical and operations superintendents have been combined at SLPRC and are performed by the operations/technical manager. This is possible because marketing is performed by other companies and transportation of crude oil or products is limited to pumping crude from the Kissy Jetty and pumping products to oil company installations.

The finance department has a prominent role, having been removed from other aspects of administration and put under a separate management. The department is headed by three fully qualified and highly experienced chartered accountants. These include the finance manager/company secretary, who coordinates activities of the board of directors and is official mouthpiece, record keeper, and overall financial chief. Next is the chief accountant, who maintains the day-to-day accounts and is in charge of stores, purchasing, salaries, and external payments. Finally, the accountant prepares budgets and reports and maintains financial records. These positions seem superfluous when one considers the scope of the company's financial operations.

In contrast, the engineering department has only five engineers with a university degree or diploma. One is fully occupied with administrative matters and one deals with planning the annual overhaul and ordering spares for maintenance. Thus, only three engineers are fully engaged in day-to-day maintenance. They are able to function well because the scope of their activities is limited to maintenance. No jobs require basic design and detailed engineering skills. When necessary, such duties have been performed by London-based BP engineers under the Technical Services Agreement.

Section heads were questioned about essential functions and the qualifications and personnel required for each one. A summary of responses (Table 6) represents only the essential functions required to keep the refinery operating. Each position may require several workers to carry out day-to-day operations. They can be trained by the essential staff.

Table 6. Functional classification of key technological personnel needed at SLPRC.

Function	Personnel required
General manager	Graduate in science/engineering with training in economics, management, and company finance.
Administration	
Public relations & personnel	One social sciences graduate.
Training officer	One sciences graduate.
Security officer	One Higher National Certificate (HNC) holder.
Engineering	
Chief engineer	Graduate engineer, 10 years' experience.
Refinery maintenance	Graduate engineer, with more than 7 years' experience.
Electrical	Two graduate engineers, one with power generation experience and the other with wiring experience.
Instrument	One graduate engineer.
Mechanical	Three graduate engineers, one for diesel and

Table 6 continued.

Function	Personnel required
	auto engines, one for pumps and compressors, and one for heavy equipment.
Engineering supervisors	Six HNC engineers, three in mechanical, two in electrical, and one in instrument engineering.
<u>Finance</u>	
Finance manager	Finance accountant (ACCA).
Chief accountant	One accountant (ACCA).
Accounting assistants	Two HNC holders, one stores supervisor and one a purchasing agent.
<u>Operations/technical</u>	
Operations/technical manager	Graduate in chemistry with work experience.
Operations	Two graduates in chemistry/engineering.
Production	One graduate in economics.
Shift controls	Four HNC holders (electrical).
Technical	One graduate in chemistry and one HNC holder (laboratory assistant).
Fire	Two HNC holders (well-trained fire officers).

The present complement of senior staff is nearly equivalent to the essential staff required by a refinery of the SLPRC's size, except in engineering. Although some section heads indicated that more staff were required by their sections, none reported experiencing work disruptions because of a lack of trained personnel. Those who claimed to need more staff seemed to require more operatives, not more essential staff. The number of trained artisans, such as welders and machinists, seemed adequate.

As a result of interviews and observations, the research team concluded that a large pool of various technical skills has been developed at the refinery and that the skills are not oil-industry specific, but can be utilized throughout the national economy by other industries.

Although useful skills exist in all departments, some departments and individuals stood out. The senior welder, for example, is of coded-welder quality, the coded welder sent by BP for the 1982 overhaul told the research team. However, because there are no facilities for inspecting his welding jobs -- a coded welder must perform an inspected coded welding job every 6 months -- he remains uncoded. Every year the technical advisers (BP) send a coded welder for the overhaul, at great expense to SLPRC. Another technician who stood out was the machinist, who seemed very adept at modifying parts and making them work.

The departments that stood out in terms of their efficiency, organization, and level of performance included:

- The fire and safety department, with seven employees, which has through vigorous safety campaigns and activities not only greatly improved the refinery's fire-fighting facilities, but also converted every employee into an efficient fire fighter and safety-conscious worker. The number of hours worked without a lost-time accident is very impressive.

- The SLPRC laboratory, which has received international recognition. SLPRC is part of a BP scheme in which samples of petroleum products are sent to various participants around the world for assay. The results are then compared with results obtained by a well-equipped central laboratory. SLPRC results have always compared favourably with accepted results.
- The maintenance engineering group, which apart from installations of new equipment, continuously makes modifications to plant and machinery and improves the refinery's general performance. Its organizational ability was demonstrated when the 1982 overhaul was finished some 3 weeks ahead of schedule.

CHAPTER VII
PERFORMANCE OF SLPRC

Data on the performance of SLPRC from the period under review (1971-83) were drawn mainly from audited and unaudited company accounts, and other tables obtained from the Bank of Sierra Leone and the Sierra Leone Central Statistics Office. Most of the data were collected between 1982 and 1984.

Productivity of SLPRC

Production figures (Table 7) for various products from 1971 to 1983 indicate that there has been product diversification over the years, an example of technical change that will be discussed more fully in the next chapter. Production of regular motor spirit (RMS) was discontinued in 1982, while industrial diesel oil (IDO) and leaded naphtha (LN) were discontinued in 1977 and 1976, respectively. RMS with a research octane number (RON) of 83 was discontinued because the company could no longer obtain foreign exchange from GOSL to import platformate. SLPRC now produces straight-run gasoline at an RON slightly above 83 so that on blending with TEL the RON could be raised to between 85 and 87 and the product sold as premium motor spirit (PMS). Production of IDO and LN was discontinued because of a lack of demand.

Also new products were started during this period. LPG was introduced in 1970, special distillate (SD) in 1977, and bunker gas oil (BGO) and marine diesel oil (MDO) in 1976. Introduction of these products was a direct response to increased demand.

PMS production increased from 1971 and peaked in 1979, at 43000 long tons. It then fluctuated at an average of about 35000 long tons. The lowest level, 26000 long tons in 1982, was caused by a general reduction in production during that year, when oil companies refused to supply more crude oil to SLPRC because of accumulated crude oil debts. That year was marked by product shortages and the accompanying hoarding and exorbitant prices on the illicit market.

Production of kerosene for domestic use (DPK) and for aviation (ATK) has increased steadily over the years, peaking in 1979. Production of automotive gas oil (AGO), another product in high demand, has remained practically constant during the period.

Production of these products -- PMS, DPK, AGO, and ATK -- for local consumption is the main task of SLPRC, and production for each one has either increased or remained constant. Other products such as fuel oil and gas oil must be dumped on the international bunker market at distress prices as bunker fuel oil, bunker gas oil, and marine diesel oil. Production of these excess products has decreased significantly over the years, from a high of 131 000 LT in 1972 to 15 000 LT in 1983. Increased production of desired products and reduced production of excess products has been achieved with fairly constant crude oil import levels.

Capacity Utilization

The SLPRC plant was designed to produce 10000 barrels per stream day (bpsd), but it has only run at full capacity during tests (Table 8). The plant has never run at full capacity. The operations department insists that while processing Nigerian crudes a throughput of 5000 bpsd is all that is required to satisfy local demand. This means the staff do not have to consider technical changes leading to capacity expansion.

Table 7. Refinery output (LT).

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Premium motor spirit	24916	27816	29901	30489	34490	33246	33020	39536	42942	35720	36854	26421	34085
Regular motor spirit	10333	9055	10760	12187	7502	6114	4455	4956	4084	5284	530	-	-
Dual-purpose kerosene	16056	17836	18282	19425	19870	23706	25215	24653	28633	27151	27446	19203	24990
Automotive gas oil	55489	50722	51477	49564	52668	50295	54129	55624	68096	66888	70952	45024	56788
Industrial diesel oil	13067	14306	12978	12332	10235	971	-	-	-	-	-	-	-
Fuel oil	25309	25218	28712	26170	23815	21758	17039	22785	16928	28377	30985	33041	30430
Lead-free naphtha	118	77	71	108	148	118	126	208	269	234	234	223	129
LPG	-	-	-	-	-	216	817	880	633	664	743	656	751
Special distillate	-	-	-	-	-	-	12	42	30	17	22	15	10
Aviation turbine kerosene	15414	16844	14609	17828	12991	13936	17393	14232	17512	16283	16340	10294	15185

Table 7. continued.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Bunker fuel oil	104922	130522	96434	53032	36280	37625	44111	37592	36744	22505	26244	10516	23229
Bunker gas oil	-	1278	-	-	2976	404	1856	9047	8612	6236	14700	4064	2836
Marine diesel oil	-	-	-	-	-	2919	4635	5875	2940	4287	2407	2443	1966
Leaded naphtha	2911	10949	-	1364	995	-	-	-	-	-	-	-	-
Total	268535	304623	263224	222499	201970	191308	202808	215430	227423	213646	227457	151900	190399

Source: SLPRC

In recent years, the supply of crude oil has been erratic and the refinery has had no control over arrival times. There have been shortages between the arrival of batches, meaning the operations department has had to process at high throughputs whenever oil became available to alleviate shortages as quickly as possible. Even when this happened, rates well below 10000 bpsd have been maintained.

Table 8. Capacity utilization at SLPRC, 1972-76.

Year	Crude blend	Crude input (long ton)	Unit time utilization	Production average (bpsd)
1972	75/25 Nig/Manjid	332000	84.4	8000
1973	80/20 Nig/Manjid	270000	60.0	9000
1974	70/30 Nig Lt/Med	237000	60.0	8200
1975	80/20 Nig Lt/Med	183000	70.4	5400
1976	80/20 Nig Lt/Med	180000	71.2	5200

Source: T. W. Russel (UN)

Financial Performance

Total product sales have increased continuously from SLL 60 million to SLL 112 million during the period (Table 9), while the exchange rate has changed from SLL 0.83 per US$ 1 to SLL 2.54/US$ 1. Similar increases are shown in the cost of sales (cost of crude oil and platformate) as well as in operating costs. However, the company did have a net profit before tax in all years shown except 1982 and 1983. These losses were mainly caused by interest payments on crude oil debts, which were owed because of the lack of foreign exchange.

Although the company enjoyed profits from the beginning, it did not start paying dividends until 1975. This was also the end of the 5-year, tax-grace period when the company started paying tax to GOSL. The dividend/tax record (Table 10) indicated that no dividends were paid in 1982 and 1983, but they were paid again in 1984 following the takeover by the first Sierra Leonean general manager.

Table 9. Financial performance of SLPRC, 1971-83.[a]

Year	Fixed assets	Product sales	Cost of sales	Gross margin	Other income	Operating cost	Profit before tax	Tax
1983	7009670	112090906	103844579	8246327	533872	6389678	(21451269)	2373526
1982	6999593	72807152	62803692	10003460	592168	4369866	(58005)	1535188
1981	6851347	103970837	94094207	9876630	236506	4365519	1405470	1600000
1980	na	na	na	na	na	na	na	na
1979	6585916	50083360	44263411	5819949	21555	3021379	2360669	1625669
1978	6390502	35859420	28134614	7724806	20936	2524244	4782113	2156780
1977	6342353	32958601	27952052	5006549	15606	2067304	2954851	1374341
1976	6256614	26015958	23953151	2062807	40997	1993685	110119	-
1975	5643304	24282998	22113740	2169258	41101	2030930	179429	-
1974	5527932	22030732	19056488	2974244	14293	1231806	1756731	-
1973	5519828	9470672	6950008	2520664	243984	883018	1881540	-
1972	5465661	6892682	6450333	442349	364758	928802	121695	-
1971	110511	5970985	5091987	878998	4520	754913	128217	_

[a] Up to the end of 1981 the value of the leone was quite close to that of the US dollar, so figures for various years may be compared. na = not available.

Profit making was the main reason for the formation of SLPRC, at least from the point of view of the oil companies.

Table 10. Taxes and dividends paid by SLPRC, 1975-81.

Year	Declared profit (SLL 1000s)		Dividend [a]* paid (SLL 1000s)
	Before tax	After tax	
1975	1200	579	579
1976	1200	579	579
1977	1000	720	382
1978	1600	720	770
1979	1461	789	1483
1980	na	na	na
1981	2456	970	970

[a] Dividends depend on annual as well as accumulated profits -- hence the variation from year to year.

Product Pricing Mechanism

To ensure the continued profitability of the company, the principal agreement detailed a pricing mechanism whereby the refining company establishes its estimated revenue requirements and the product realization at current prices for the next year before the end of each year. If there are any shortfalls, an advisory committee is set up to recommend new prices to offset the shortfall and make the company profitable again. After approval by the board price recommendations are submitted to GOSL for approval; after which the new prices go into effect. With the exception of 1978 there has been at least one ex-refinery price increase every year

Table 11. Inland petroleum product[a] price trends, 1969-81.

Date		PMS	RMS	DPK	AGO	IDO	FO	LFN
	Ave.IG/LT	295	310	275	260	260	240	310
01-Jan-69	SLcents/IG	10.6	8.6	10.5	9.1	8.1	6.6	5.0
01-May-72	SLcents/IG	13.6	11.6	10.5	13.1	11.1	10.6	5.0
01-Feb-73	SLcents/IG	21.6	19.6	12.5	17.1	15.1	14.6	5.0
08-Dec-73	SLcents/IG	38.6	36.6	22.5	31.1	29.1	28.6	5.0
01-Feb-74	SLcents/IG	46.6	44.6	33.5	41.1	39.1	38.6	5.0
03-Jan-75	SLcents/IG	56.6	54.6	34.5	43.1	41.1	39.6	20.0
09-Dec-75	SLcents/IG	62.6	60.0	39.5	48.1	46.1	43.6	45.0
25-May-76	SLcents/IG	72.6	70.6	49.5	48.1	46.1	43.6	45.0
01-Feb-77	SLcents/IG	87.6	85.6	64.5	48.1	-	43.6	45.0
01-Apr-79	SLcents/IG	98.6	96.6	75.5	89.1	-	49.6	na
01-Mar-80	SLcents/IG	153.6	150.6	104.5	83.1	-	61.6	na
01-Feb-81	SLcents/IG	248.6	-	104.5	199.1	-	147.6	na

[a]RMS regular motor spirit; DPK domestic purpose kerosene; AGO automotive gas oil; IDO industrial gas oil; PMS premium motor spirit; LFN lead-free naphtha; IG imperial gallon; LT long ton; and FO fuel oil.

since 1972 (Table 11). In the years in which crude oil prices were increased considerably, two or more price increments were allowed.

The price the consumer pays is determined not only by the ex-refinery price, but also by the excise duty and marketers' margin. In Table 12 we show ex-terminal prices (ex-refinery plus marketers' margin) together with excise duty and actual prices paid by consumers for some main products.

In general, GOSL in the past tended to avoid fuel price increases or to allow as small an increase as possible, usually allowing larger increases for products that do not have an immediate direct effect on the public. The national economy is sensitive to fuel prices and an increase in them is reflected immediately in increased transportation costs and food prices, which eventually lead to demands for higher wages, and so on. Some fuel price increases in recent years have led to rioting in many of the major cities. In some cases fuel prices were subsidized in Sierra Leone (note the reduction of excise duty on PMS, RMS, and DPK in 1976 and again in 1977).

In 1982 the prices for petroleum products in Sierra Leone were among the lowest in countries that did not produce oil. However, the foreign exchange crisis was aggravated and GOSL could no longer provide SLPRC with enough foreign exchange to purchase crude oil from the oil TNCs, so GOSL took over the obligation of providing it with crude oil. At the same time, GOSL started negotiating with the International Monetary Fund (IMF) for US dollar loans, and one loan condition was the removal of all subsidies on petroleum products. Thus, between July 1982 and July 1983 pump prices for PMS rose twice, from SLL 3.40/imperial gallon (IG) to SLL 5.00/IG and then to SLL 6.75/IG. There was another price increase early in 1984, to SLL 8.00/IG. There were similar price increases for all other petroleum products.

Table 12. Sierra Leone light petroleum product price trends (SLcents per imperial gallon).[a]

	Premium motor spirit			Regular motor spirit			Kerosene			Automotive gas oil		
	Ex-terminal	Duty	Price	Ex-terminal	Duty	Price	Ex-terminal	Duty	Price	Ex-terminal	Duty	Price
01-Apr-72	36.50	31.00	67.50	32.50	31.00	63.50	27.50	12.00	39.50	26.50	24.00	50.50
01-Jun-73	44.50	28.00	72.50	40.50	28.00	68.50	29.50	14.00	43.50	30.00	24.00	54.00
08-Dec-73	63.50	21.00	84.50	59.50	21.00	80.50	41.50	10.00	51.50	46.50	19.00	65.50
01-Feb-74	72.00	28.00	100.00	68.00	28.00	96.00	53.00	14.00	67.00	57.00	24.00	81.00
03-Jan-75	82.00	28.00	110.00	78.00	28.00	106.00	54.00	14.00	68.00	59.00	24.00	83.00
27-Jun-75	82.00	36.00	118.00	78.00	36.00	114.00	54.00	14.00	68.00	59.00	32.00	91.00
09-Dec-75	89.00	36.00	125.00	85.00	36.00	121.00	60.00	14.00	74.00	65.00	32.00	97.00
25-May-76	99.00	31.00	130.00	95.00	31.00	126.00	70.00	9.00	79.00	65.00	32.00	97.00
01-Jan-77	114.00	31.00	145.00	110.00	31.00	141.00	85.00	9.00	94.00	65.00	32.00	97.00
28-Jan-77	114.00	40.00	154.00	110.00	40.00	150.00	85.00	9.00	94.00	65.00	32.00	97.00
01-Jul-77	120.00	31.00	151.00	116.00	31.00	147.00	91.00	9.00	100.00	71.00	32.00	103.00
19-Feb-79	125.00	31.00	156.00	121.00	31.00	152.00	92.00	9.00	101.00	76.00	32.00	108.00

[a] Ex-terminal prices are paid by oil company marketing affiliates, duty is paid to GOSL, and price is what the consumer actually pays.

Source: BP Sierra Leone Ltd.

During interviews, SLPRC management reported that in 1983 GOSL, instead of reviewing SLPRC price increase proposals with the intention of minimizing them, tended to maximize them. GOSL wanted to use the increases to reduce consumption in order to reduce heavy import bills. A one-step price increase from SLL 3.40/IG to SLL 8.00/IG had been contemplated in 1982, but politically the incremental increase must have been more palatable for the government.

The efficiency and performance of SLPRC did not directly affect the availability and prices of petroleum products. Other factors, such as marketers' margins, excise duty, availability of crude oil, and petroleum products, availability of foreign exchange, and the IMF, seem to have had greater influence on the prices paid by consumers.

Effect of External Factors on the Performance of SLPRC

Foreign exchange shortages meant not only a shortage of crude oil but also a reduction in spare-part stocks, and the company now has to wait longer for major replacement parts. These shortages have so far postponed general overhauls for up to a year, but they have not caused a total production stoppage.

This illustrates the careful manner in which SLPRC carries out scheduled plant inspection during annual overhauls. Each major part of the plant, such as pumps, vessels, and major pipes, has an inspection schedule that was determined from a previous inspection. For example, the crude oil/gas oil heat exchanger was replaced in the 1982 general overhaul. Ultrasonic measurements of pipe thicknesses the previous year had revealed the rate of corrosion. The plant inspection team suggested that the exchanger need not be inspected again until 1989.

The estimate of the next inspection date is obviously made with 1 or

2 years to spare so that delays in annual overhauls will not unduly endanger the operation of the whole plant. In other words, a systematic inspection program exists and because of it the impact of foreign exchange shortages on SLPRC operations is minimized. A plant inspector and coded welder are the only two "experts" SLPRC now requests from BP for its regular overhauls. (Coded welding and plant inspection are required for insurance purposes.)

Other economic problems do not seem to have had much effect on SLPRC performance because the company is not directly involved in marketing its products -- all are sold directly to TNC subsidiaries. Such factors as overvaluation of the leone, the existence of a thriving black market for petroleum products, particularly during shortages, and the poor state of infrastructural development, especially the road network, do not affect SLPRC's operation directly. The country has been experiencing electric power shortages recently because of fuel shortages and machine breakdown, but this has not affected SLPRC; its generator switches on automatically within 30 seconds of a power failure.

CHAPTER VIII

TECHNICAL CHANGE AND EXISTENCE OF TECHNOLOGICAL CAPABILITY AT SLPRC

In this study technical change is regarded as the ultimate manifestation of the existence of technological capability in a company. The study has looked for incremental technical changes and at their effect on company productivity. We have also looked for any creation of an indigenous technology and tried to relate the performance of technical change to learning.

Technical change may affect: output volume parameters; output mix parameters; output quality parameters; and throughput parameters. An attempt was made to evaluate technical changes at SLPRC according to their effects and, hence, to determine the direction of the changes.

Technical changes may be introduced to increase production capacity; to improve product quality; to reduce unit cost; to introduce new products; and to react to a falloff in product quality or to respond to increased demand.

Changes that result from a deliberate effort by personnel to render the plant more efficient or to stretch its capacity toward or beyond its design limits are indicative of some rudimentary research and development capability. Such capability will eventually generate new and indigenous technologies.

In contrast, technical changes that are externally motivated, such as those carried out in response to increased demand or falloff in product quality, do indicate the existence of a capability to run and to maintain a production plant. This type of capability is really the beginning of the last stages in the sequence: transfer and acquisition of technology, development of a technological capability, including capability for adapting foreign technology, and generation of a local technology.

The research team observed that a host of technical changes are carried out at SLPRC rather routinely. Most are minor and are effected in response to some minor bottlenecks encountered in maintenance. Monthly engineering reports from the maintenance engineer to the chief engineer describe all engineering duties undertaken during the month and detail many "modifications" and "fabrications" of small and major replacement parts.

Many of these qualify as technical changes when performed for the first time. Classified here as routine technical changes, they occur continuously at SLPRC, especially within the engineering departments.

Major Technical Changes

Major technical changes are those that, for example, have wider personnel participation or have measurable effects on refinery performance. Table 13 displays a list of major refinery assets. By 1972 SLPRC had acquired the plant, land, and water tanks from GOSL. The extension of the refinery clinic in 1973 is considered a scale-multiplying change. The technical changes start with the installation of the standby generator and include all items marked with an asterisk. The table also provides the chronological sequence of major technical changes. The following section gives a sample of major technical changes, grouped according to objectives for which they were introduced.

Introduction of New Products

In response to local demand for LPG, a feasibility study was carried out and indicated that the project was economically feasible. The capital costs were approved by the directors, and installation of the LPG

Table 13. Schedule of main assets of the refinery.

Asset	Year of purchase	Cost (SLL)	US $/SLL exchange rate	Cost (US$)
Land	1969	165000	1.2000	198000
Water	1969	14400	1.2000	17280
Process plant: 10 000 bpsd distillation, merox unit for kerosene and naphtha, crude oil and products storage, laboratory, stores and workshop buildings	1972	5034907	1.2000	6041888
Extension to clinic	1973	3560	1.1980	4265
Standby generator[a]	1974	144640	1.1980	178279
PPD scheme[a]	1974	3338	1.1980	3999
Crude blending manifold[a]	1974	6527	1.1980	7819
Tank farm lighting[a]	1974	5858	1.1980	7018
Refinery power installation	1974	24180	1.1980	28968
Crude transfer pump[a]	1974	16536	1.1980	19810
Extension to laboratory	1975	3225	1.1980	3864
LPG production scheme[a]	1976	332480	0.8190	272600
Administration building	1976	330684	0.8190	270830
Storekeeper's office	1976	2333	0.8190	1911
Fire station	1979	78332	0.9457	74079
Gate	1980	2350	0.9295	2148
Air circulating system[a]	1982	3775	0.8175	3086

[a] Major technical changes at SLPRC.

production unit was carried out by SLPRC staff with the help and supervision of a BP expert, whose job was to ensure that all specifications, as well as BP safety standards and practices, were strictly followed.

The local food and plant industries required white spirit. SLPRC produced a special distillate that had similar properties, except for a different flash point. This product proved acceptable to industry and is now produced regularly.

Changes to Increase Production and Production Capacity

Steam is required in the crude column for stripping volatile substances from kerosene and gasoline, and the Marshall boiler was installed to produce it. Since the automatic boiler required soft water for its input, a Permutit softener was also installed. These changes were made to increase productivity and improve the quality of kerosene and gasoline.

SLPRC usually receives power from the National Power Authority. From 1971 to 1973 there were frequent power failures, 51 in 1971 and 28 in 1973, and each meant the plant shut down. To overcome this problem, staff installed a standby generator. BP supervised the installation and made sure that BP standards and safety practices were adhered to, but the bulk of the installation was done by local staff.

To Improve Product Quality

Pipe works leading to Shell, Mobil, and Texaco installations were modified so that ATK could be pumped through a separate line, with PMS, DPK, and GO pumped through another line. Black oil goes through a third line, ensuring minimum contamination of products, especially ATK, which must meet strict international specifications.

To Reduce Unit Cost

In 1971, '72, '73, and '74 the price of crude oil increased considerably and SLPRC could not increase prices fast enough to keep pace. A lower throughput was required, but at the same time local demand had to be satisfied.

During this period the demand for fuel oil was falling because large ships were no longer refueling in Sierra Leone. It was necessary to reduce fuel oil production by cutting deeper into the fuel oil fractions for gas oil. A larger gas oil/fuel oil ratio can be obtained from lighter crudes, but lighter crudes are more expensive because they contain a higher percentage of the more expensive products, such as kerosene and gasoline. Therefore, changing to lighter crudes would not only mean the production of more gas oil at the expense of fuel oil, but also of more gasoline and kerosene at lower throughputs.

The SLPRC thus set its equipment to process lighter Nigerian crudes. It started with a 60/40 mixture of Nigerian light/medium, then went up to 70/30, 80/20, and 90/10; it now processes 100% Nigerian light crude. By going to lighter crudes, SLPRC was able to satisfy the local market at lower throughputs and thereby solve the dual problems of escalating crude oil prices and changing domestic consumption patterns. The lower throughput apparently offset the higher cost of lighter crudes.

This is perhaps the SLPRC's single most important technical change, indicating that there is a technological capability in oil refining and that the capability is not merely static. It shows that the company can produce a strategic response to ensure its viability in face of severe external factors. The evidence available to the research team indicated that the SLPRC staff planned and executed this change with no significant foreign input.

The use of lighter crudes causes some technological problems. Lighter crudes are waxy and since a deeper cut is taken from the fuel oil, its pour point rises and must be depressed. Initially the pour point of fuel oil was depressed by adding some kerosene and gas oil, but this meant a reduction in the gains made by going to lighter crudes. It was thus uneconomical to use diluent to depress the pour point of fuel oil, and a new technique had to be used. The company finally settled for a pour-point depressant -- a chemical additive that affects only the pour point. With a PPD the advantages of lighter crudes were regained.

The change to lighter crudes necessitated the use of blending equipment and vessels with accompanying pumps, valves, and flow meters, and these were installed by SLPRC staff a saving on installation cost.

A gasoline tank developed leaks and had to be rebuilt. A novel approach was taken; the foundation and frame were left intact and sheets of metal were removed piece by piece and replaced with new ones. This meant a great reduction in cost and was so innovative at the time that two engineers from a Nigerian refinery were invited to observe. The technique was developed by BP, but the repairs were carried out by local staff, with BP supervision to ensure proper safety practices.

After several years of use, cooling water pipes become corroded, narrowing the pipes and reducing water flow and cooling efficiency. The use of a corrosion control chemical in cooling water prevents the very costly replacement of pipes and prolongs their life by preventing further corrosion. Ammonia and Kontol are now used regularly in heat exchangers, overhead condensers, and even in the crude oil column.

Safety and Preventive Maintenance

Safety and preventive maintenance seem to be the most appropriate way to describe the reasoning behind several technical changes at SLPRC. Eventually these changes led to increased production by preventing work stoppages and to lower unit operating costs by reducing maintenance bills.

The story of Hockadate boiler repair narrated at the IDRC workshop on Science and Technology in Monrovia in November 1982, led us to select SLPRC for a case study. The Hockadate boiler had broken down, the steam chamber cover had developed a crack, and the boiler feed water pump had stopped. The maintenance engineer at the time was an expatriate and he immediately suggested ordering the faulty parts from the United Kingdom. The Sierra Leonean mechanical engineer suggested that the repairs could be done locally at much lower cost and with much less boiler downtime, and was told to carry out the repairs locally. The pump was completely stripped and rebuilt and some pump parts and the steam chamber cover were fabricated by the national railway workshop. The repaired boiler is reported to have worked trouble free for many months.

An impingement plate was inserted in the crude column where hot crude oil enters the column. This preventive maintenance was intended to prolong column life.

Heater tubes are operated at high temperatures and they carry crude oil that can be acidic. The original tubes are gradually being replaced by tubes made from a more resistant alloy. This preventive maintenance will avoid costly accidents that tube breakage could cause.

A major fire-fighting main was constructed around the processing area, tank farm, and administrative building. The system was later extended to the jetty, where unlimited water can now be brought from the sea via cement-lined pipes. Construction of the water main was suggested during a safety audit.

Other safety technical changes carried out recently include:

- First aid and safety training with certification;
- A company car that had been written off and was about to be sold was

converted into an ambulance;

- Vessels to be welded are now filled with foam; they were filled with water before, but this does not eliminate vapours completely. Foam does, so its use is safer;
- Cleaning leaded tanks requires expatriate specialists and could be quite costly to SLPRC. Company procedures have been devised that are quite safe and cost nothing beyond normal operating costs;
- A new safety manual has been prepared by refinery staff, and an emergency procedure booklet is carried by each employee.

Effect of Technical Change on Product Mix

There has been variation in the product mix (Table 14). New products like LPG and SD were introduced in 1976 and 1977, respectively, in response to local demand.

Production of regular motor spirit was terminated in 1982 because of severe foreign exchange shortages. SLPRC could no longer import platformate (Table 15) to blend with straight-run gasoline (SRG) in order to obtain premium motor spirit (PMS) with a research octane number (RON) of 93. Production patterns were therefore changed so that an SRG was obtained; when blended with tetraethyl lead it yielded a product with an RON of 87. This is now marketed as a single product, PMS.

Production of marine diesel oil (MDO) started in 1976. Importation of MDO was stopped in March 1976 (Table 15). Subsequently only the occasional barrel was imported, as local demand was being satisfied by SLPRC.

The termination of production of industrial diesel oil coincided with the beginning of MDO production. These two products are really the same. The introduction of MDO is therefore not a technical change, but rather a scale-multiplying change. The total production of diesel oil dropped in

1976 from 5% to 2% of the total (Table 14).

Effect of Technical Change on Production Capacity

The SLPRC distillation plant, designed to refine 10000 barrels of crude oil per day, has never operated at that rate except during trial runs. It is now known that local demand can be completely satisfied with the plant running at half its rated capacity.

This, plus the fact that the principal agreement requires SLPRC to produce only for the local market, shows that there is no incentive for staff to stretch plant capacity. Therefore, there have been no technical changes with capacity extension as the primary objective.

Some technical changes have had increased productivity as one objective. Two of these were discussed in the last section. It has not been possible to estimate the actual increase in production caused by these changes. However, the 1974 annual report records that there were no shutdowns caused by power failure, and boiler maintenance appears to have been reduced to a minimum.

Effects of Technical Change on Product Quality

SLPRC product quality has always been high. This is partly because of the laboratory's vigorous quality control efforts. Sampling and analysis of products are done at regular intervals during processing and reports are given to the operations superintendent, who makes adjustments and uses blending to correct errors already made. With this continuous sampling, testing, and adjusting, product quality has remained high.

As a result of quality-control consciousness, a separate ATK pumping

Table 14. Refinery production; products as percentages of yearly totals, 1971-83.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Premium motor spirit	9.28	9.16	11.32	13.70	17.08	17.38	16.28	18.37	18.09	16.72	16.03	17.06	17.90
Regular motor spirit	3.85	2.98	4.07	5.48	3.71	3.20	2.20	2.30	1.72	2.47	0.23	-	-
Dual-purpose kerosene	5.98	5.87	6.92	8.73	9.84	12.39	12.43	11.44	12.06	12.71	11.94	12.40	13.13
Automotive gas oil	20.66	16.72	19.48	22.28	26.08	26.29	26.69	25.84	28.68	31.30	30.86	29.06	29.83
Industrial diesel oil	4.87	4.71	4.91	5.54	5.07	0.51	-	-	-	-	-	-	-
Fuel oil	5.42	8.38	10.87	11.73	11.79	11.37	8.40	10.59	7.13	13.28	13.48	21.31	15.98
Lead-free naphtha	0.04	0.03	0.03	0.05	0.07	0.06	0.06	0.10	0.11	0.11	0.10	0.14	0.07
LPG	-	-	-	-	-	0.11	0.40	0.41	0.28	0.31	0.32	0.42	0.39
Special distillate	-	-	-	-	-	-	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Aviation turbine kerosene	5.74	5.55	5.53	8.01	6.43	7.28	8.58	6.61	7.38	7.62	7.11	6.65	7.98
Bunker fuel oil	39.07	42.98	36.50	23.83	17.96	19.67	21.55	17.46	15.48	10.54	11.42	6.79	5.38
Bunker gas oil	-	0.42	-	-	1.47	0.21	0.92	4.20	3.63	2.92	6.39	5.11	8.31
Marine diesel	-	-	-	-	-	1.53	2.29	2.73	1.24	2.91	1.05	2.62	1.03
Leaded naphtha	1.08	3.61	-	0.61	0.49	-	-	-	-	-	-	-	-

Source: SLPRC end-of-year accounts

Table 15. Production cost (SLL/LT) of products, 1971-83.

Years	Raw material cost	Transformation cost	Total cost	% Raw material cost	% Transformation cost
1971	19.01	2.83	21.84	87.0	13.0
1972	21.30	3.04	24.34	87.5	12.5
1973	26.34	3.27	29.61	89.0	11.0
1974	87.58	5.54	93.12	94.1	5.9
1975	93.18	8.56	101.74	91.6	8.4
1976	124.99	10.39	135.38	92.3	7.7
1977	138.77	10.20	148.97	93.2	6.8
1978	131.74	11.73	143.47	91.8	8.2
1979	192.56	12.73	205.29	93.8	6.2
1980	325.78	17.83	343.61	94.8	5.2
1981	406.65	18.99	425.64	95.5	4.5
1982	413.30	28.21	441.51	93.6	6.7
1983	546.01	33.56	579.57	94.2	5.8

Source: SLPRC end-of-year accounts

facility to Shell, Mobil, and Texaco terminals has been installed. DPK, PMS, and GO have another system and fuel oil uses a third. ATK, which is used to refuel aircraft at Freetown International Airport, is as free of contamination as possible. Because the fuel is used by jets at high altitudes, it must meet high standards, and SLPRC makes a special effort to keep the product within specifications.

Effect of Technical Change on Unit Cost

The most significant technical changes at SLPRC were introduced to cut the cost of production, which has two components: the cost of raw materials and the cost of refining. A comparison of these two components indicates that the cost of raw materials has increased more than 20-fold and the cost of refining more than 10-fold (Table 15).

The increase in the cost of raw materials was obviously caused by several jumps in world oil prices, but the reason for the increase in refining cost is mainly the decline in the value of the leone. At the start of the period the exchange rate was SLL 1.00 per US$ 1.24, but at the end of the period the rate was SLL 1.00 per US$ 0.17. While the unit cost of production by raw materials rose from 87% to 94%, the refining cost declined from 13% to about 6%. A series of remarkable technical changes contributed significantly to this. The first was the selection of lighter crudes and adjustment of the plant to produce more of the products in high local demand. This change, more than any other, ensured survival of the company following the crude oil price hikes. There were also price increases that ensured profitability.

The decline in real value of the leone contributed only to the yearly increases in the actual cost of production. It did not affect the reduction in the relative percentage contribution of the cost of refining to the cost of production. This could only have resulted from the technical changes.

The impact of changing the type of crude oil on reduction of unit input cost is seen most directly in imports of feedstocks relative to 1971 values (Table 16). The total amount of feedstock utilized started to decrease in 1973 and continued to drop until 1977, when the amount used was a good 30% below the 1971 value. The biggest drop in a single year occurred in 1973 and seems to have been the strategic response to the 1973-74 crude oil price hikes, when the cost of crude oil quadrupled.

Table 16. Amount of crude oil and platformate imported relative to 1971 values.

Year	Relative volume of crude oil
1971	100.0
1972	108.8
1973	91.0
1974	86.6
1975	74.5
1976	69.7
1977	68.3
1978	80.3
1979	84.2
1980	79.8
1981	79.1
1982	54.9
1983	66.1

Source: SLPRC

A simple calculation indicates that the increase in cost per ton of SLL 61 (1973-74) was completely offset by the average accumulated product price increase of SLL 0.24 per IG, with an average of 260 IG per LT.

Technical change reduced the amount of raw material needed to satisfy demand, while price increases offset increases in the cost of crude oil.

Effect of Technical Change on Safety and Preventive Maintenance

Several technical changes were aimed at plant and personnel safety. In the long run they will also reduce the cost of production, but the most direct consequences were a safer work environment and longer equipment life span. Thus new fire mains make the refinery safer, while chemical injection into pipes to prevent corrosion increases safety and makes equipment last longer, eventually reducing maintenance costs.

This type of change is important because it is internally motivated. Although its effect is difficult to detect in end-of-year accounts, the fact that the plant and its utilities have been operating for such a long period proves that they have been protected and well maintained.

Preventive maintenance is important because it involves research. This includes gathering and inspecting information, making conclusions about problems, and executing a planned program of repairs and modifications. The key aim is to anticipate machine performance and deterioration. This is, in fact, a modest type of research and development.

At SLPRC the planning and coordination of maintenance are carried out by the development engineer. His functions include planning a schedule for testing or inspecting various parts of the plant. Parts that have deteriorated to dangerous levels are repaired; otherwise, the date for the next inspection for the part is set. The development engineer also ensures that parts and supplies needed for preventive and regular maintenance are ordered well in advance so that downtime during planned maintenance is kept at a minimum.

Contribution of Various Divisions to Technical Change

The engineering division is responsible for major plant and building modifications, installation of additional equipment, and alterations of equipment and machinery. It also plans preventive maintenance and ensures that proper spares and supplies for engineering projects are made available.

The laboratory also plays an important role in technical changes, collecting reliable data on which important decisions are based. For very big projects, such as the LPG plant, its role has been limited to sampling and chemical analyses; computer simulations and process design are done elsewhere. Its role before and after a technical change is very important. Before the change it collects data to determine potential results; afterwards it collects data to show that expected results have been achieved.

Usually the laboratory section is involved in controlling the chemical and physical parameters of products and in quality control involving crude oil. It participates in plant experiments designed to test new crudes or newly installed machinery, or merely to change the production pattern to meet changing demand. These duties mean the laboratory section will always be directly involved in technical change.

The operations department sets plant parameters in order to try to obtain optimum yield from new crudes. It also determines the best operating conditions for new equipment.

The production section does market-type research and development, which determine the production pattern adopted by the operations group.

The safety department has modernized safety practices and emergency procedures. The emphasis is on preventing disasters, but adequate preparations have been made for dealing with emergencies.

In many instances technological guidance was provided by BP under the Technical Services Agreement. When major pieces of equipment are added to the plant, the design, basic engineering, and detailed engineering are contracted out by BP. However, installation is effected by SLPRC staff, with some supervision by BP. Supervision is invariably limited to ensuring that design specifications and BP safety standards are followed.

When asked about the contributions of expatriates during various installations, junior staff at SLPRC said BP experts contributed little. These junior workers do not understand the significance of strict adherence to specifications. However, SLPRC management must be aware of this need,

Table 17. Foreign exchange (US$) needed by SLPRC, excluding those for feedstock, 1975-82.

Year	Technical Services Agreement	Foreign contract
1975	13500	356021
1976	58627	568540
1977	63025	305364
1978	138545	356095
1979	128442	850343
1980	136265	323948
1981	662642	2861192[a]
1982	309070	10706

[a] This figure includes some accumulated debts as well as forward payments for 1982.

Source: Bank of Sierra Leone

because it continues to approve a relatively large expenditure for expatriate contracts every year (Table 17).

The technical changes described earlier seem to have boosted staff confidence, for it is now easier for changes to be proposed, accepted, and implemented. This was indicated by the increased number of times the monthly engineering reports recorded "modifications" and "fabrications" after 1979. Another indicator is that the engineering department is supervising construction of a new laboratory building on its own. Some experience was gained in 1982-83 when the main fire building was constructed using outside supervision.

Learning and Technical Change at SLPRC

In this section an attempt will be made to link technical change at SLPRC with ongoing learning that would produce some capabilities at SLPRC.

Technical changes can arise in response to sharply changed external circumstances, such as the technical changes that accompanied oil price increases. Other examples include the technical changes that accompanied shifts in demand for products such as LPG and GO. Such changes will be classified as being exogenously based.

Technical changes can also be exogenously stimulated, being made in response to anticipated changes in value and composition of effective demand. Here there is no danger to company profits; chemical cleaning of pipes carrying cooling water in order to reduce corrosion and then the continued use of the process to prevent further corrosion is an example.

A third type of technical change includes those that are endogenously motivated, arising because plant personnel want to increase efficiency. This category includes all preventive maintenance practices and improvements in operating procedures because of greater familiarity with equipment.

All major technical changes involve learning.

The change to lighter crude oil is an example of crisis-induced learning. Crude oil prices were escalating, but the political climate would not permit unlimited increases in product prices. The company needed a strategic response to ensure its survival, so production systems were adjusted to use lighter crudes that would reduce the throughput while producing roughly the same amount of high-demand products and reducing production of low-demand ones.

The first change was from Manjid crude oil from Gabon to Nigerian bonny medium/light 30/70. Once the original change was successful, the company found it easier to implement subsequent changes, indicating that there was some learning by doing.

Installation of the standby generator and LPG plant provide two other examples of learning. In both cases the electrical installations, in particular, were done entirely by local SLPRC staff. SLPRC had inherited from the Japanese the Sierra Leonean electrical wiring technician who wired the plant during the construction phase. The company also employed a Sierra Leonean electrical engineer who had some power-generation experience with the National Power Authority. These two employees knew more about the plant's electrical layout than any expatriate contractor could possibly learn within the short duration of any installation. They are usually responsible for the electrical portion of major installations.

There was some learning during the construction and in the early days when the plant was still being developed. By employing an electrician who had participated in the construction, SLPRC acquired knowledge about the wiring of the plant. Similarly, employment of a local, experienced electrical engineer was far more cost effective than employing a younger graduate and sending him to the power authority for the necessary experience.

Similar comments can be made about the mechanical engineering section, in which the senior welder was an apprentice welder during the construction phase, and an experienced Sierra Leonean mechanical engineer was hired soon after start-up. The story of the Hockadate boiler indicates the high level of local mechanical engineering expertise during SLPRC's early days. These examples indicate learning from the construction phase as well as through employment of experienced personnel.

Another example of learning by doing involves supervision of construction of the new laboratory building by the engineering department. SLPRC engineers had been involved in several building projects in the past in which they participated in the construction at some level, but not as project supervisors. Through experience gained from the previous projects, SLPRC can now supervise the construction of one of its own buildings.

The main evidence of learning at SLPRC, however, is associated with the many minor "modifications" and "adaptations" carried out by the maintenance department, changes that are endogenously generated. After many years of operating the plant the engineers understand their equipment well enough to recognize modifications that will improve the overall performance of various parts of the plant. For these changes, no specific external technological inputs are required. They are planned and executed by company personnel, usually in response only to the desire to improve the plant.

For learning to take place, plant personnel had to possess certain capabilities. The analysis of technical changes at SLPRC indicate:

- The capability to react successfully when required to meet urgent exogenous demands;
- The capability to anticipate the emergence of pressures or opportunities; and
- The capability (and concern) to generate and to improve the plant via minor modifications.

CHAPTER IX
SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

In this chapter the major conclusions of this study are summarized and its policy implications discussed.

Obviously, some indigenous and dynamic technological capability in oil refining exists within the Sierra Leone Petroleum Refining Company. In particular, the company has demonstrated the capacity to react to exogenous demands, to anticipate pressures and opportunities, and to effect improvement.

The specific capabilities within SLPRC are:

- Capability in production engineering (maintenance and repair of existing plant and machinery);
- Capability to make minor changes to process;
- Capability to run the company safely and profitably for 10 or more years;
- Capability to make minor changes to plant and machinery in order to improve performance or to prolong lifetimes; and
- Capability to train another team to run a refinery that is similar in complexity to the one run by SLPRC and up to two times the size.

These capabilities have been established without explicit intervention by GOSL on matters of technology transfer. The employment strategy adopted by the refinery's technical advisers has certainly hastened the development of a technological capability. SLPRC recruits Sierra Leoneans who are already qualified and who have some relevant experience. By doing this the technical advisers hoped to avoid elaborate training schemes and at the same time to lower personnel costs, since a national could always be employed at a fraction of the cost of an equally trained and experienced expatriate. Because oil refining technology was transferred quickly to well-trained Sierra Leoneans, and because their training was usually in science, engineering, or economics, they could easily adopt and internalize the technology.

The main evidence for the existence of a technological capability is based on a review of technical change at SLPRC, where several major technical changes have occurred. These changes are usually supervised by the technical advisers, who ensure that specifications and accepted safety standards are followed. Local workers always play a major role in making these changes and there is evidence that some learning is taking place because of them.

The most significant technical change was in response to escalating world crude oil prices. Minor technical changes aimed at preventive maintenance and safety are carried out regularly by the indigenous staff. These changes are internally motivated and indicate a dynamic capacity to make adaptations to plant and machinery.

The plant has always operated at throughputs well below its design level, so there is no incentive for the staff to try to stretch refining capacity.

Technical change by SLPRC has resulted in product diversification, maintenance of high product quality, reduction of unit costs, improved personnel and plant safety, and longer plant, equipment, and machinery life.

The principal agreement allows SLPRC to produce only for the local market. Over the years production of gasoline, kerosene, and gas oil, which are in high local demand, has remained high or increased, while production of fuel oil, which is in low demand, has declined and raw material throughput has also declined. This indicates greater productivity.

Profitability has always been the main concern of oil companies participating in the joint venture. A pricing mechanism in which the next year's revenue budget is reviewed at the end of each year and price increases are recommended to offset any expected shortfalls ensures this profitability. The company has been profitable and shareholders have been paid dividends for most of the company's lifetime, except recently when foreign exchange shortages have rendered the company insolvent.

Lack of foreign exchange is the main external factor affecting SLPRC performance, causing shortages of crude oil and spare parts. Because of adequate forward planning, shortages of spares have not yet led to work stoppages, but they have caused postponement of annual overhauls. Availability of crude oil determines the product supply in the market.

Prices paid by consumers for petroleum products are determined by foreign exchange availability, marketers' margins, and excise duty. The efficiency of SLPRC is not a major factor.

Simplicity of process and the limited scope of operations at SLPRC are two factors that have helped technology transfer. Refining consists of straight atmospheric distillation, stabilization, and blending to yield products. There is no thermal cracking, hydrocracking, catalytic reforming, or alkylation. The maximum throughput is 10000 bpsd (some units elsewhere in the world have throughputs of 600000 bpsd). SLPRC does not market or transport products or carry out basic or detailed engineering of plant equipment that is to be installed. As well, plant inspection is not done by SLPRC. The lack of complexity means technology can be transferred quickly.

The organization of employees is similar to that found in other refineries. All essential functions are performed by Sierra Leoneans and there is an adequate body of skilled technicians to carry out day-to-day operations.

The two agreements that govern SLPRC were negotiated during the postinvestment phase, when there was no explicit science and technology policy in Sierra Leone. Therefore, it is no surprise that both agreements contain very little in the way of effective technology transfer clauses -- transfers depend on the benevolence of the TNCs. Some transfer of technology has taken place because of an employment policy adopted by the TNCs in order to reduce costs.

The crude oil supply arrangement of the principal agreement, which gave the TNCs the sole right to supply crude oil from sources of their choice, quickly led to problems:

- The supplied crude was more expensive than that which could be obtained in the open market; and
- SLPRC had to pay for crude in foreign currency, while the TNCs paid for products in local currency.

These problems have resulted in SLPRC accumulating a huge foreign exchange crude oil debt and becoming insolvent in recent years.

GOSL did not carry out adequate feasibility studies before embarking on the refinery project. At the end of the investment phase there was need for a large sum of money to finance a refinery company that would be solvent and to start up the plant. The oil TNCs cashed in on the government's uncertainty about investing more money in a new company by forming a joint venture company with GOSL. Some of the company's financial success may be attributable to the oil TNCs' search for profits, but their 50% ownership of the company means GOSL does not have full control of a strategic industry for development of the country.

Some policy recommendations have been derived from a careful consideration of the conclusions.

- GOSL should negotiate to take over 80% of the refinery so as to be in control of a strategic industry for development; a long-term loan should be used to finance the takeover.
- The refinery should be operated at full capacity, and the excess products sold to neighbouring countries to generate more foreign exchange for crude oil purchases. Installation of a catalytic

reformer should be reconsidered in this light.

- All dividends should henceforth be paid in leones.
- All contracts awarded by SLPRC should be awarded to Sierra Leoneans, who can then subcontract to foreign firms, if necessary. In all foreign subcontracts local participation and training should be mandatory.
- Regular training visits of all SLPRC staff to refineries owned by the TNC participants, at the TNCs' expense, should be arranged as part of the TNCs' contribution to technological capability development in Sierra Leone.
- There should be mandatory reinvestment of some TNC profits in other sectors of Sierra Leone's economy.
- TNCs should be asked to train a plant inspection team and to arrange for coding of the refinery's better welders.
- The laboratory and mechanical workshops and the fire and safety departments should be upgraded and their activities expanded so that they can provide some services to other sectors of the national economy.
- In future, all new projects should be studied carefully and technological capability accumulation built into the project -- Sierra Leoneans must be involved in feasibility studies, process engineering, and detailed engineering as counterparts from the start. They should be involved at the investment stage and at the start-up so that they can benefit from the learning that goes on in these phases. There should be firm timetables for training Sierra Leoneans to replace expatriates, as well as funding schemes for such training programs.
- All technologies purchased should be disaggregated so that only core technologies are bought. Peripheral technologies should be acquired locally.

- Technical services agreements covering many areas should be replaced by technology transfer agreements, which are project oriented. The latter concern a single project; all expatriates employed under such an agreement will be required to perform a specific function and they will be understudied by a Sierra Leonean counterpart. Specific training programs would be organized under such schemes.
- A planning unit should be established to evaluate all future projects in terms of personnel needs and to determine where and how workers should be trained, so that as the project starts technology can be transferred immediately.

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REFERENCES

Arthur O.S. The commercialization of technology in Jamaica. Mona Jamaica, ISER Caribbean Technology Policy Studies Project, 1978.

Bank of Sierra Leone, Economic Review, 16 (1 and 2), 1982.

Bardouille R.K. Technological aspects of the bauxite industry in the Caribbean. Mona Jamaica, ISER Caribbean Technology Policy Studies Project, 1977.

Barrio, S., and Parisca, S. Technological learning process: a conceptual framework derived from a practical experience. Paper prepared for the Research and Policy Workshop on Technology Problems for the Caribbean, August 1983.

Bell, L.M. The accumulation of technological capability and the economic consequences of its use: a case study of the cassava starch flour industry in Thailand. SPRU/IDRC Research Workshop No. 2, 1977 (mimeo).

Cooper, S. Science, technology and production in underdeveloped countries: an introduction. Journal of Development Studies, 9 (1), 1972.

Dahlman C.J. From technological dependence to technological development: the case of the Usiminas Steel Plant in Brazil. IBD/ECLA Research Program in Science and Technology Policy, Buenos Aires, 1978, working paper 21 (mimeo).

Farrell T. A tale of two issues. In Girvan, N., ed., Essays on Science and Technology Policy in the Caribbean, Mona, Jamaica, ISER, 1979.

Fransman M. Technological capability in the Third World: an overview and introduction to some of the issues in technological capability in the Third World. New York, Macmillan, 1984.

Girvan, N. The approach to technology policy studies. Essays on Science and Technology Policy in the Caribbean. Mona, Jamaica, ISER project, 1979.

Girvan, N. Notes on technological capability. Caribbean Technology Policy Studies, Phase II, Port-of-Spain, Trinidad, May 1981.

Girvan, N. Technology policies for small developing economies. Mona, Jamaica, Caribbean Technology Policy Studies Project, ISER, 1983.

Girvan, N. Some thoughts on technology development in the Caribbean. Globus Lecture, City College of New York, April 1984.

Hirs ch, W.Z. Firm progress ratios. Econometrica, April 1956.

Hirschman, A.O. Development projects observed. Washington, DC, Brookings Institution, 1967.

Jones, G.I., and Purves, D. Refining note. Freetown, Sierra Leone, SLPRC, Report to BP London, 1982 (mimeo).

Katz, J. Importacion de tecnologia aprendizaje e industrializacion dependiente. Mexico, DF, Fondo de Cultura Economica, 1976 (quoted in Maxwell, 1976).

Koroma, A.B. The Sierra Leone Petroleum Refining Company Ltd. A Report to BP London by Deputy General Manager of SLPRC, 1982 (mimeo).

Lewis, A.W. Economic development with limited supplies of labour. In Agarwala, A.M., and Singh, S.P., ed., Economics of Underdevelopment, London University Press, UK, 1958.

Maxwell, P. The traffic in technology. New Internationalist, July 1973.

Maxwell, P. Learning and technical change in the steel plant of Acindar S.A. Buenos Aires, Argentina, IBD/ECLA Research Program on Science and Technology, monograph 4, 1976.

McIntyre, A., and Watson, B. Studies in foreign investment in the Commonwealth Caribbean, 1. Trinidad and Tobago, Mona, Jamaica, ISER, 1970.

Oddle, M. Technology leasing -- Guyana and Trinidad. In Girvan, N., ed., Essays on Science and Technology Policy in the Caribbean, Mona, Jamaica, ISER, 1979.

Smith, A.J. Technological capability in oil refining: Sierra Leone. Ottawa, Canada, Progress Report to IDRC, 1984 (mimeo).

Steward, F. Technology and underdevelopment. New York, Macmillan, 1977.

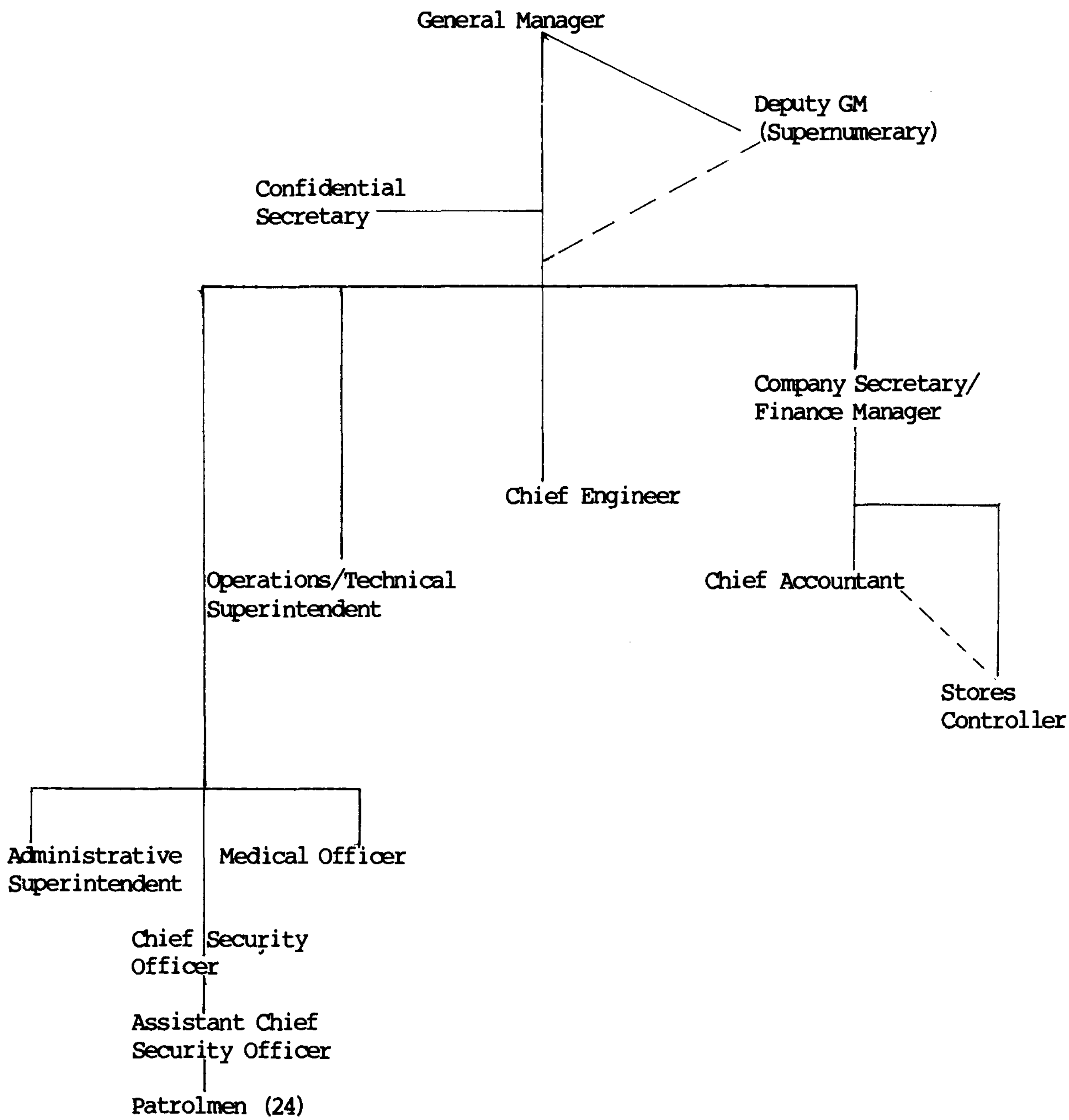
United Nations Conference on Trade and Development (UNCTAD) Transfer of Technology. Santiago, Chile, Report by the UNCTAD Secretariat TD/106/Corr. 1, 1972.

United Nations (UN). Multinational corporations in world development. New York, UN, 1973.

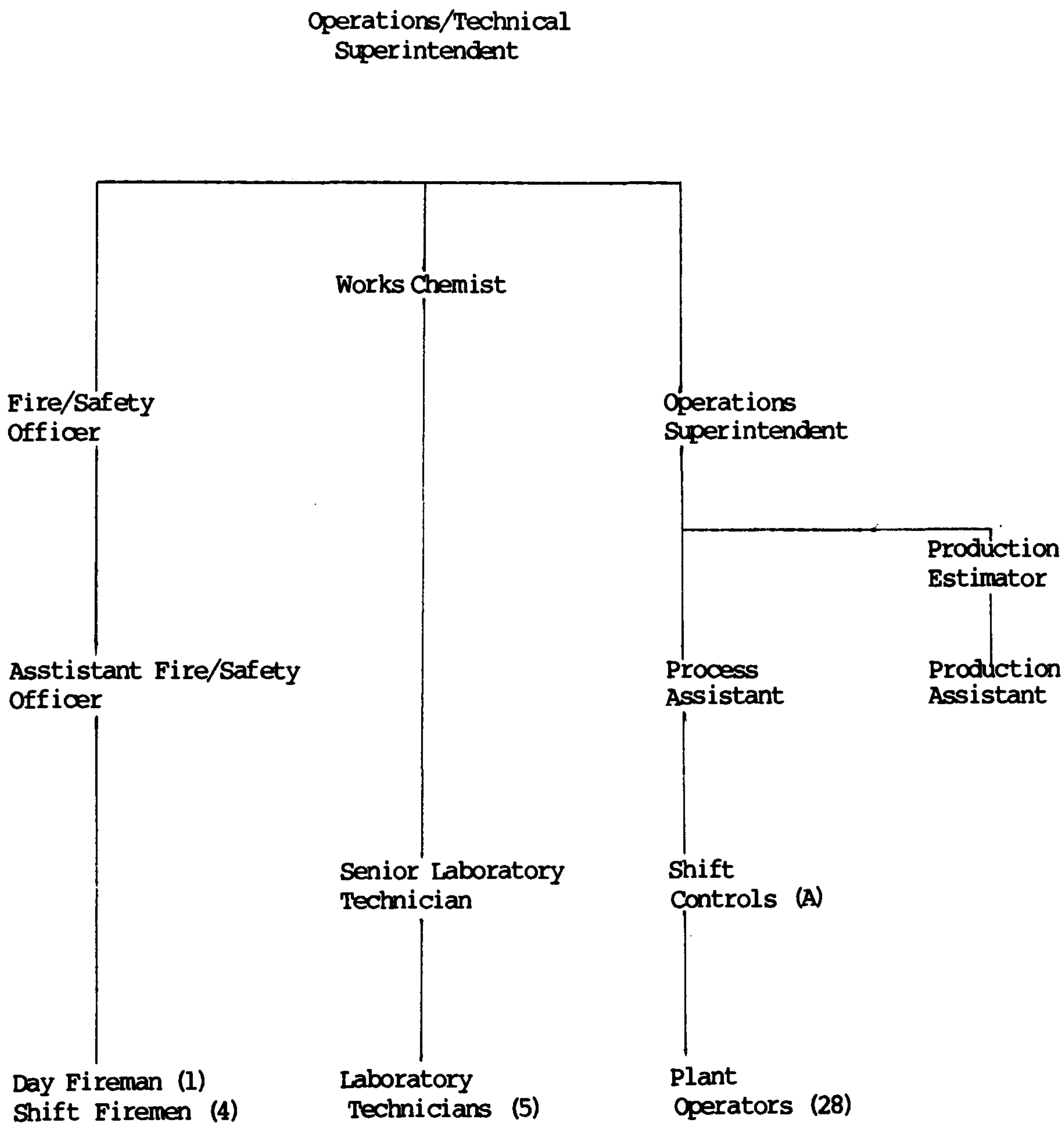
Vaistos, C.V. The process of commercialization of technology in the Andean Pact. In Radice, H., ed., International Firms in Modern Imperialism, Harmondsworth, Penguin, 1975.

World Bank, Accelerated development in subsaharan Africa: an agenda for action. Washington, DC, World Bank, 1979.

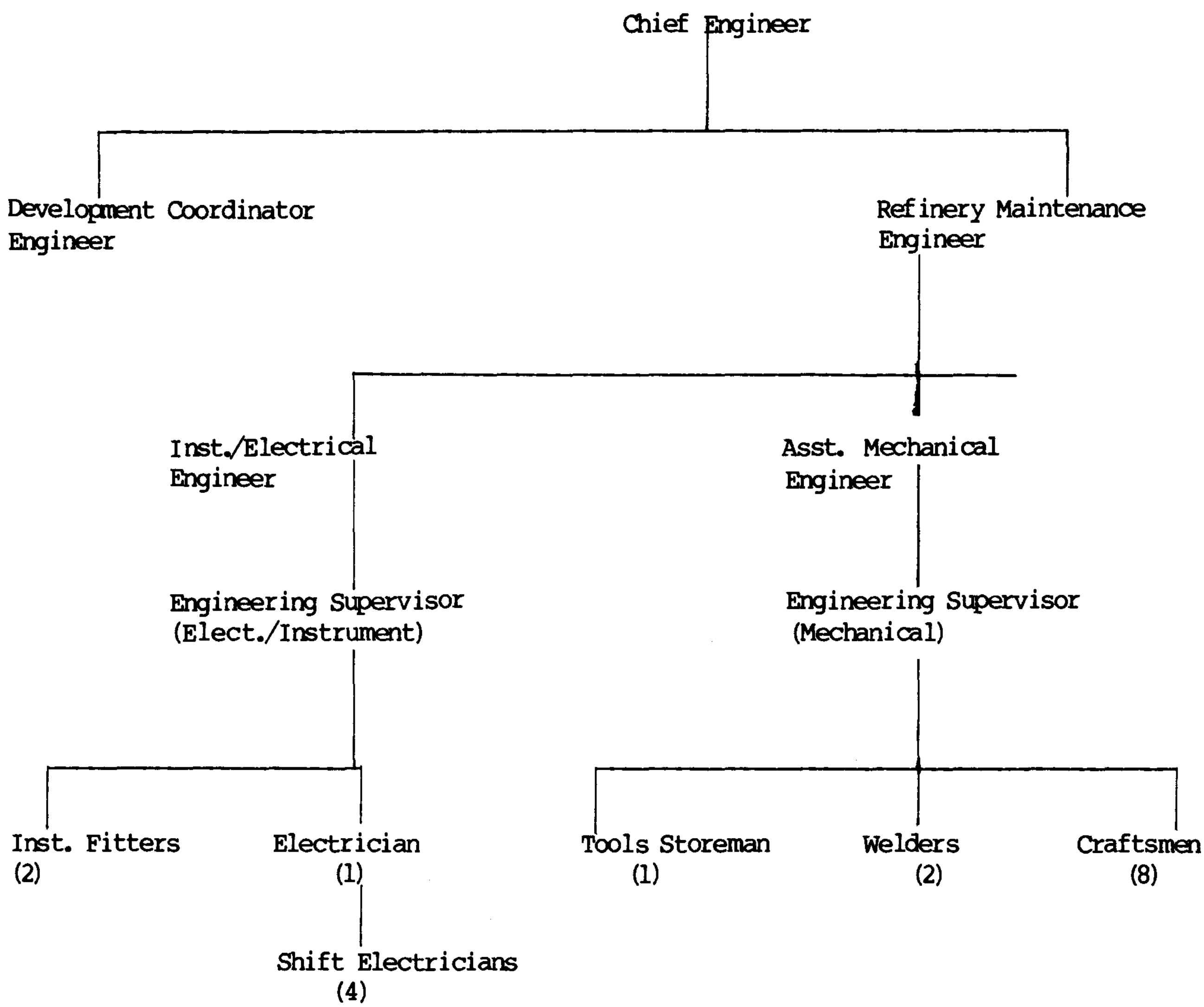
Appendix A-1
Top Administrative Setup



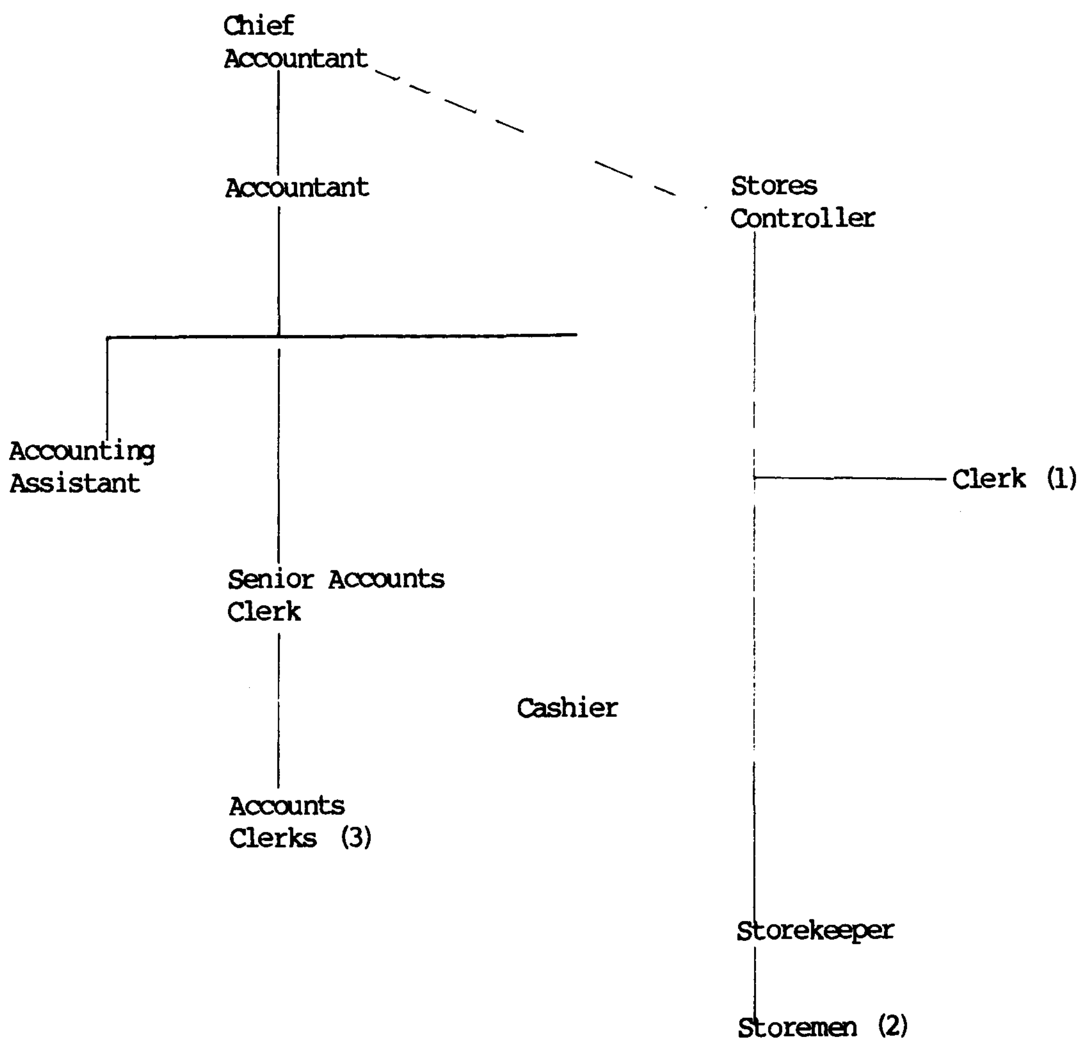
Appendix A-2
Operations and Technical Departments



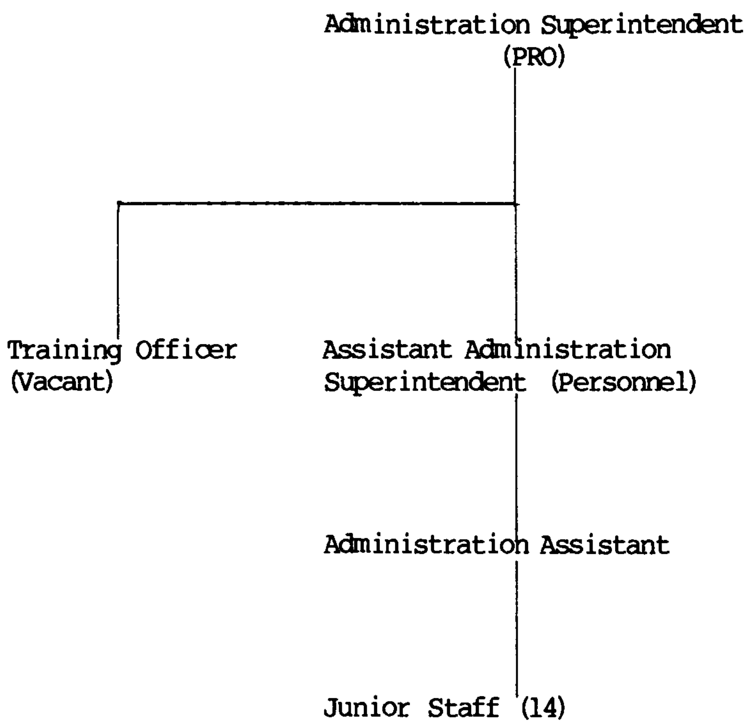
Appendix A-3
Engineering Departments



Appendix A-4
Accounts Department



Appendix A-5
Administration Department



Appendix B-1
General Assistance under Technical Services Agreement
October 1981 to October 1982

Since the commencement of the current agreement on Oct. 1, 1981, general assistance has been provided in respect of the following matters:

Request Date	Assistance Requested	Date Replied
21.10.81	Advise on service life of CFR engines	28.10.81
04.11.81	Cost/availability of technical publications	05.11.81
12.11.81	Equipment costs for budget	23.11.81 23.12.81 29.12.81 05.01.82 11.02.82 24.02.82
05.01.82	Materials for pump casing repairs	18.01.82
18.01.82	Equipment cost for budget	01.02.82
20.01.82	Shelf life of SR Kits for overhaul	22.01.82
11.05.82	Servicing of standby generator	23.06.82
11.05.82	Replacement of stripping ejector	12.10.82
09.06.82	Disposable pens for chart recorders	07.09.82
10.06.82	Crude column scaffolding	28.07.82
06.08.82	Pension fund	14.10.82
30.09.82	Translucent sheeting	06.10.82

Date	Publication/Document
08.03.82	Proceedings Maintenance Engineers Meeting No 2 dated 20.09.82.
16.03.82	Refinery News Volume 2 Number 2.
24.05.82	Volume 1 of Methods of Testing.
15.06.82	Guidelines to Management on Safety Auditing in BP Group.
17.06.82	Guidelines for preparation of Safety Policy Statements.
21.06.82	Environmental Bulletin distribution.
23.06.82	BP ICPMS Review.
23.06.82	Measurement Guidelines Part 1 Volume 1.
01.07.82	Minutes of 1982 Works Chemists' Meeting.
09.09.82	Annual Safety Report 1981.
21.09.82	Failures of Inert Gas Systems on Crude and Oil Product Tankers at Company Terminals.
18.10.82	Refinery News Volume 13 Number 1.

Source: BP London

Appendix B-2
Visits Under Technical Services Agreement

1. **Visits to SLPRC**

Note: P.G. Brackley, general manager, PCG, visited the refinery in December 1977 for 4 days of discussion with SLPRC and government.

1978

Technical

March/April	M.S. Binns, PID; 1 month — plant inspection for refinery overhaul. J.A. Murrie, CED; 1 month — technical appraisal of refinery instrumentation. D. Bingham/G. Robbins, Sonarmarine; 1 week — underwater survey of QEII berths 5 and 6.
May	D.A. Blair, PCG; 3 days — safety re-audit of refinery.
June	A.D. Webb, Eng; G. Ransom, Mertech; 1 week — operational problems with generator and panel.

Coordination

May	G. Jones, PCG; 1 week — familiarization and general discussion.
July	D.W. Clift, SPP; 1 week — disposal of fuel oil surpluses.

1979

Technical

February/April	P. John, CED; 2 1/2 months — training of instrumentation personnel.
March	B.W. Archer, PID; 1 month — plant inspection for refinery overhaul.

May K. London/G. Jordan; Assoc. Octel; 3 days — TEL discussions/ bulk-delivery schemes.

Coordination

May D. Purves, PCG; 2 days — familiarization and operation of TSA.

Note: Regular direct contact with the refinery is also made by P.S. Waghorn during his attendance at SLPRC board meetings.

2. **SLPRC Visits to UK**

1979

April J.D. Okrafo-Smart, chief accountant; 1 month — training course with ACD, PSD, PER, and Llandarcy refinery.

June A.B. Koroma, superintendent, operations/technical; 1 month — training course with PCG, GRD, ENG and at Kent refinery.

Notes: 1. SLPRC management expatriates Baker, Watson, and Borley also normally visit BP for general discussion during annual UK leave.

2. P.G. Brackley hosted the chairman of SLPRC, Crispus Cole, at the International Petroleum Annual Dinner in 1978 and 1979.

3. **1980 Visits to SLPRC**

January A.L. Tebbit, T.J. Cox — site technical surveys, operational and energy conservation.

March B. Archer (Llandarcy); 1 month — inspection for refinery overhaul.

April/May D. Purves; 1 week — TSA coordination visit.

4. **SLPRC Visits to UK**

1980

April/May	A.M. Kaloko, fire/safety officer; 2 months — training course with safety coordination, selected BP refineries, equipment manufacturers, PITB fire leaders course.
October	A. Akiwumi, refinery engineer; 1 month — see commercial proposal/training sale London (J. Ansdell).

1981

March	B. Archer (Llandarcy); 1 month — overhaul assistance. D. Purves; 1 week — TSA coordination visit.

1982

February	D. Gavroway; 2 days — familiarization visit combined with BP SL/West Africa tour.
March	J. James, PID London and R. Beattie; 1 month — overhaul assistance.
June	A. Cardemie, Shell Chemical; 2 days — Shellswim 5 discussions.
July	A. H. Deakin/ R.N.T. Smith/D.J. Beer; West Africa familiarization visits.

Source: BP London

PROCESSING OF 90/10 WT/WT NIG.LT/NIG.MED CRUDE OIL BLEND