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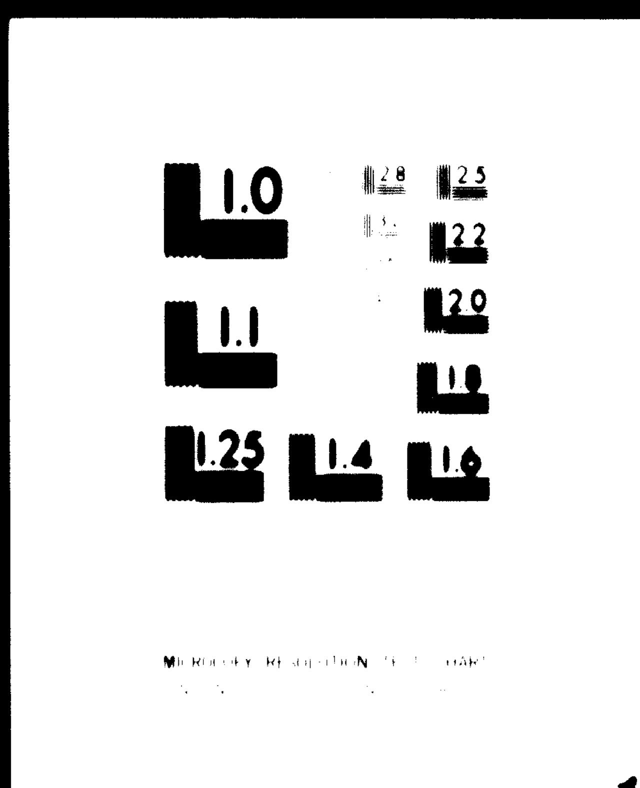

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UNIDO CONTRACT NO. 73/42
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06751

FEASIBILITY STUDY ON SYNTHETIC RUBBER INDUSTRY IN KUWAIT

Report prepared for the United Nations Industrial Development Organization acting as Participating and Executing Agency for the United Nations Development Program

JAPAN GASOLINE CO., LTD.
TOKYO, JAPAN
SEPTEMBER 1976

CONTENTS

SYNOPSIS

The Government of Kuwait requested UNIDO to conduct a feasibility study on a synthetic rubber industry in Kuwait by utilizing its indigenous raw material, and UNIDO entrusted Japan Gasoline Co., Ltd., with this feasibility study.

This study covers product selection, technical study, economic study and recommendations on the project.

Product Selection

Polybutadiene rubber (BR) is selected as the most recommendable rubber to be produced in Kuwait. The appropriate plant capacity is recommended to be 25,000 tons per year. The recommendable start-up date of production is set for 1981. The reasons are as follows:

(1) As a result of market study and demand forecast covering the countries in the Middle East, North and East Africa, a part of Europe and West Asia as well as Kuwait, total prospective demand for BR and styrene butadiene rubber (SBR) produced in Kuwait is shown below.

	1980	1981	1982	1983	1984	1985	1990
B R	16,000	17,800	20,700	22,400	25,000	28,400	48,000
SBR	22,500	25,400	28,200	31,100	34,700	38,300	61,800

Since the synthetic rubber industry in Kuwait is highly export-oriented due to its limited domestic market and some countries have their plans to produce SBR first, the BR would be expected to find much prospective market in the neighbouring countries.

(2) The following factors on comparison of BR and SBR are taken into consideration in the final selection of BR.
Since minimum economical plant size of BR (20,000-25,000 tons/year) is smaller than that of SBR (40,000-45,000), the BR plant can be expected to operate at a higher operating factor in the earliest stage.
The BR production is expected to operate easilly because it requires a lesser number of chemicals and it produces lesser kinds of grades than those of SBR.

Technical Study

BR is produced from butane, which is the only currently available indigenous raw material in Kuwait, via a series of processes which consists of butane dehydrogenation, butadiene extraction and BR production.
Information on these process technology and facilities such as the nature of the processes, availability of licencing, description of recommendable process including process flow scheme and major equipment & machinery list, and brief description of offsite facilities are presented in the report.

The plant will be located at the Shuaiba Industrial Area which has been selected for the setting up of an ideal industrial complex in Kuwait since 1964.

Overall construction period including detailed design and test operation is estimated to be thiry-four months after contracting.

For operating, managing and maintaining the plants, around 280 personnel will be required.
The required number of personnel with their qualifications and a recommendable example of the organisation structure are presented in the report.

Economic Study

Total capital requirement is estimated to be 93.26 million U.S. dollars on a 1976 basis.

Production costs of MA during a recommendable projection period are estimated as follows:

1981	1,354 U.S. dollars per ton
1982	1,230
1985	1,077
1990	1,039

They are based on a butane feedstock of 120 dollars per ton. In view of the fact that the current price of MA is around 830 dollars in the international market, competitive position of the Kuwait-made MA in the international market would be unfavorable.

Though a cash inflow will turn into a plus in the second year after starting the operation, the total cash inflow over the entire study period is small compared with the capital requirement. It would indicate that this project is not economically feasible.

The high production cost of BR is mainly caused by high price of butane feedstock.
As a result of analytical study on the production cost, the project will become feasible if the butane is supplied at a price of around 30 dollars per ton and butadiene production section is scaled up to 90,000 tons per year.

Recommendations

Vocational training is recommended for plant management and operation personnel. The report covers a recommendable training procedures and curriculums for engineers, foremen and operators individually.

It is also recommended for the successful implementation of the project that an implementing agency be set up and a partner who has extensive experience in the rubber industry be selected. The selected partner would be expected to license BR production technology and to render technical and marketing assistance.

I. Introduction

(1) Background

While the economy of Kuwait is mainly based on export of petroleum and natural gas, its programme of economic development has aimed at the industrialization of the country based on a total utilisation of hydrocarbon resources.

One of the objectives of the First Five-Year Economic Plan which started in 1967 was to diversify Kuwait's economy through development of its industries other than oil and gas production sectors. In the petrochemical field, The Petrochemical Industries Company was established in 1963 for promotion of various segments of its petrochemical industry based on Kuwait's natural resources. Presently two large fertiliser plants are operating in Kuwait using natural gas as raw material, and studies are also underway on construction in the near future of olefine and aromatics plants.

In the Shuaiba area, which has been designated as the site for the above industries, utilities and port facilities to support the industrial development are being constructed or expanded by the Shuaiba Area Authority.

These industrial products of Kuwait, as in the actual case of fertilizer, are to be exported to its neighboring countries.

Against this background, the Government of Kuwait requested UNIDO to conduct a feasibility study on commercialization of the synthetic rubber industry under its economic development programme, who, in turn, entrusted Japan Gasoline Co., Ltd., with this feasibility study.

(2) Objective

The objective of this feasibility study is to provide assistance to the Government of Kuwait in establishing its policy for viability of its synthetic rubber industry.

This study discusses the most recommendable type of synthetic rubber to be produced that we have selected, and the appropriate plant capacity and its start-up date that we recommend, based on the investigation of the availability of raw materials in Kuwait and the domestic and export markets for its synthetic rubber.

To this end, Japan Gasoline Co., Ltd., is to provide the Government of Kuwait with preliminary technical information on production technology and facilities and also give recommendations on plant management.

(3) Outline of Synthetic Rubber

The present total world production of synthetic rubber amounts to approximately 7.5 million tons. There are many kinds of Synthetic rubber, each of which has various grades.

Synthetic rubber is classified by their usage into general-purpose rubber and special-purpose rubber. As for general-purpose rubber, its kinds are styrene butadiene rubber (SBR), polybutadiene rubber (BR) and isoprene rubber (IR). Because of their low prices, they are used in large volumes as substitutes for natural rubber in tire manufacture.

Of the total production of all synthetic rubber, general-purpose synthetic rubber account for well over 80%, of which SBR, BR and IR account for 62%, 14% and 7%, respectively.

With respect to special-purpose rubber, its kinds are nitrile butadiene rubber (NBR), isobutylene isoprene rubber (IIR), ethylene propylene copolymer (EPR) and chloroprene rubber (CR). They account for only less than 20% of the total production of synthetic rubber. They are supplied to the fields of products requiring oil-resistance, airtightness and thermal resistance of rubber. Table I-1 and I-2 show the characteristics of these synthetic rubbers and their present worldwide demand and supply situation.

In response to the growth of automobiles and tires, world synthetic rubber demands continued remarkable growth in the past decade, at an annual average rate of as high as 8.8%.

However, though demands for tires are assumed to keep an annual growth rate of more than 8% in East European countries and developing nations in the years ahead, worldwide tire demands would remain around 4%, because of much lower growth rates in North America, West Europe and Japan.

Accordingly, reflecting the tire demands, the annual growth rate for world synthetic rubber demands are estimated at approximately 4.4%. On this basis, worldwide synthetic rubber demands in 1985 would be 12,100,000 metric tons/year.

This study discusses SBR and BR as promising products to be produced in Kuwait in consideration of their wide uses and the availability of their raw materials.

Table I-1 Characteristics of Synthetic Rubber

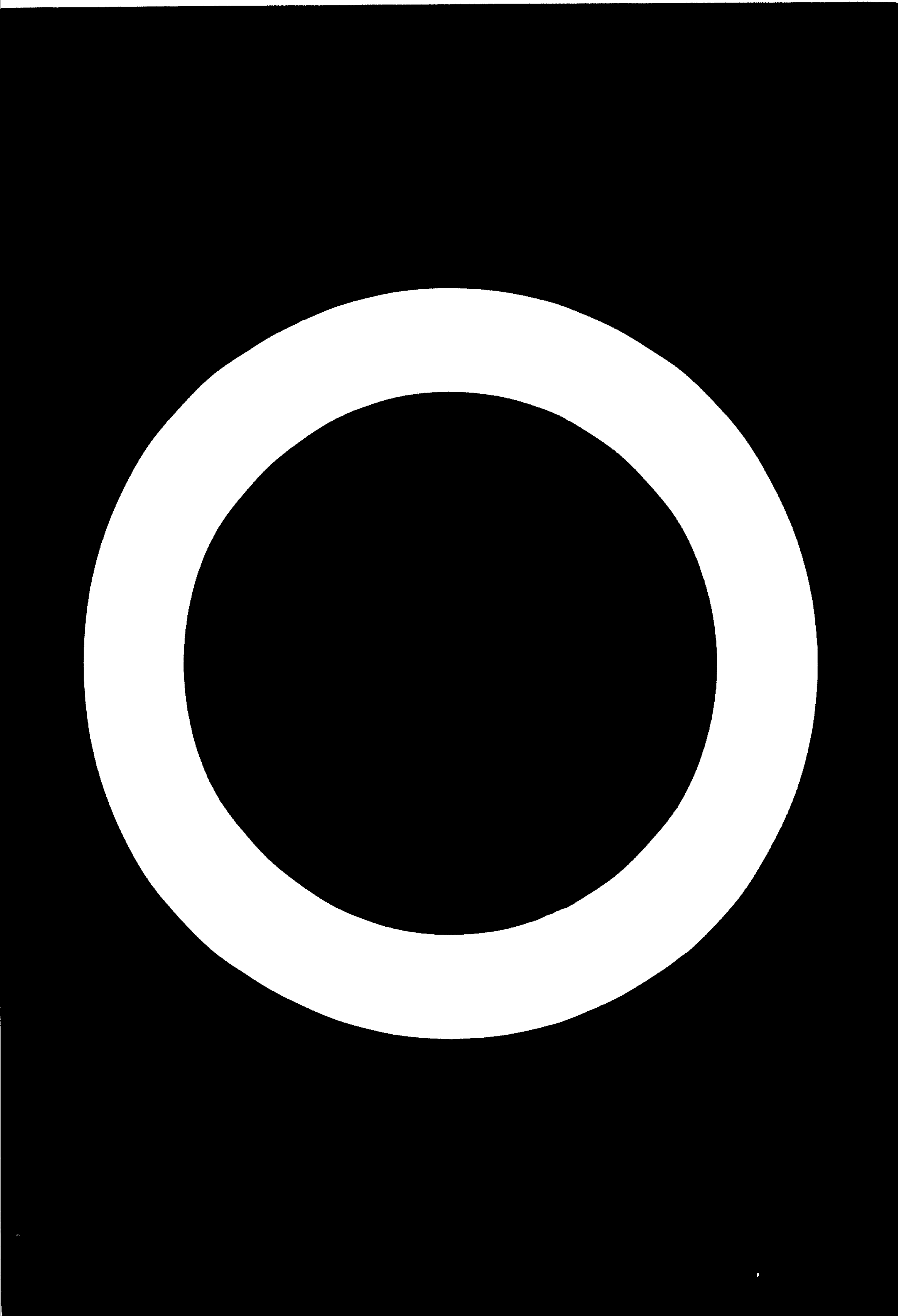
	World Production Capacity * 1000TONS	Major Raw Material	Major Applications	Advantages
SBR	5,743	Butadiene Styrene	Tires, Tire products, Footwear, Hose, Tube, Belt, etc.	Abraision resistance Antiaging property
B R	1,242	Butadiene	Tires, High impact polystyrene, Hose, Belt, etc.	Abraision resistance Rebound resilience Good low temperature properties
I R	633	Isoprene	Tires, Tire products, Footwear, Belt, Mechanical rubber goods.	Abraision resistance Good antiaging property
NBR	334	Acrylonitrile Butadiene	Hose, Oil seals, Gaskets, O-rings	Oil resistance Good abraision resistance
IIR	426	Isobutene Isoprene	Tire inner tubes, Tire inner liners, Coated fabrics	Air retention properties Weathering resistance Good antiaging property
EPR	309	Ethylene Propylene	Tires, Non tire automotive products, Hose	Weathering resistance Chemicals resistance Good Abraision resistance
C R	448	Chloroprene	Wire and cable, Hose	Weathering resistance Flame resistance Oil resistance

* 1974

Table 1-2 World-wide Synthetic Rubber Demand and Supply Situation in 1973

(in 1,000 metric tons)

	Production	Import	Consumption	Export
World	7,438	1,858	7,270	1,840
USA	2,517	113	2,389	279
Canada	209	81	181	89
North America	2,726	194	2,570	368
West Germany	317	179	339	154
United Kingdom	327	116	271	160
France	463	139	308	276
Italy	250	120	250	101
Netherlands	245	71	62	208
Others	145	323	468	74
Western Europe	1,747	956	1,718	973
Czechoslovakia	50			4
East Germany	139			70
Poland	101			25
Rumania	96			39
Others	1,308			98
Eastern Europe	1,694	224	1,600	236
Japan	858	26	615	238
Australia	45	24	64	2
China	50	n.a.	65	n.a.
Brazil	135	40	166	1
Argentina	50	n.a. (Argentina and Mexico)	n.a. (Argentina and Mexico)	16
Mexico	66			6
Others	67	394	472	4



II. Product Selection

II-1. Synthetic Rubber Market

(1) Market Study

a) Purpose of Market Study

The purpose of the market study in the present study is to forecast the size of domestic and export markets for the synthetic rubber to be produced in Kuwait.

Such forecast will serve as a basis for the selection of the types of synthetic rubber to be produced, decision of the plant capacity, and determination of the timing of start-up. Economic evaluation of the project will also be based on this forecast of the market.

b) Countries to be studied

Presently there is no manufacturer of tire and other rubber products in Kuwait. Production of 13,000 tons/year of tire is being planned by 1970, but it would not be justified to set up a synthetic rubber industry solely dependent on this domestic tire production because its requirements for synthetic rubber would be only around 3,000 tons/year.

Thus, consideration to export markets is necessary for this study. From a geographical viewpoint, the Middle East, North and East Africa, West Asia and a part of Europe are selected as potential market areas. And within the above areas, those countries who have their domestic tire manufacturing industries (including those in the planning stage) are chosen as subject countries of this market study.

The countries chosen are as follows:

Middle East: Iran, Iraq, Syria, Saudi-Arabia, Turkey
North Africa: Egypt, Libya, Sudan, Tunisia, Algeria, Morocco
East Africa: Kenya, Tanzania, Zambia, Ethiopia
Europe: Yugoslavia, Greece
West Asia: Pakistan, India

c) Methodology of Demand Forecast

Methodology of forecasting the demand for synthetic rubbers in each country is summarised in Fig. II-1.

The following is a brief discription of the key steps of the forecast.

a. Estimation of Present Demand

Demand for synthetic rubbers in 1975 is estimated in the following way based on the most up-to-date statistics available as well as on the findings of the field survey. For countries where only past data are available adjustment to the 1975 is made by use of correlation of rubber demand with growth of GNP.

Tire

Demand for tire is estimated on the basis of such data as the number of registered cars, production and import of cars, and annual average rate of tire replacement. For some of the countries, information collected directly from existing tire manufacturers are also utilised.

For the annual average rate of tire replacement, relevant data in Japan is used as a guide, that is; 1.37 tires for a passenger car, 3.5 for a truck and a bus, and 1.16 for a pick-up truck.

To estimate the requirements for synthetic rubber to make various types of tires, the total requirements for all kind of rubbers are estimated in the first place, and then blending ratio of synthetic rubbers is taken into consideration. For reference, average quantity of rubber required for a tire in Japan is 4 - 5kg for a passenger car tire, 24 - 30kg for a tire for truck and bus, and 4.5 - 6kg for a tire for pick-up truck. And average blending ratio of synthetic rubbers for tire manufacturing in the United States and Japan are as shown in the following table:

Table II-1 Assumed Average Synthetic Rubber Blending Ratios (in %)

	Synthetic Rubber			Natural Rubber
	SBR	BR	Others	
Passenger Car Tire	60	17	3	20
Truck and Bus Tire	27	10	3	60
Pick-up Truck Tire	60	17	3	20

These figures are used as a guide but some adjustment is necessary, because rubber requirements as well as blending ratio vary to a considerable extent country by country. For example, they are affected by weather and road conditions. In natural rubber producing countries, the blending ratio of natural rubber is naturally higher, while in a country where SBR is produced domestically a higher blending ratio of this synthetic rubber is conceivable. In our estimation, such specific factors in each country are taken into consideration.

Non-Tire Product

Requirements for synthetic rubbers for non-tire rubber products are estimated in a similar way as used in the estimation of requirements for tire manufacturing. Major non-tire usages of synthetic rubber are for shoes, sandals, and such industrial products as belt, hose, and tube. Demand for these items are estimated on the basis of past production and import/export statistics and the requirements for synthetic rubbers are calculated based on a assumed rubber composition: 25 - 30% SBR by weight and a small quantity of other synthetic rubbers such as BR.

Table II-2 shows the demand for SBR and BR of each country in 1975 estimated by the above mentioned method.

Table II-2 SBR and BR Demands in 1975 (in tons)

	SBR	BR
Kuwait	2,200	700
Iran	23,500	5,500
Iraq	3,500	600
Syria	2,900	400
Saudi-Arabia	5,100	1,400
Egypt	3,400	1,600
Libya	3,000	1,000
Sudan	2,200	600
Tunisia	3,000	900
Algeria	4,600	600
Morocco	6,000	900
Yugoslavia	42,300	9,600
Greece	7,700	800
Turkey	23,700	900
Pakistan	2,400	1,200
India	30,000	1,000
East African Countries	5,000	1,400
Total	170,500	29,100

b. Forecast of Future Demand

Demand for SBR and BR from 1980 to 1990 of the countries chosen are forecasted based on the estimated demand in 1975. The method of forecast is as the following:

Increase in demand for tire and other rubber products is known to have good correlation to growth of GNP, and coefficients of the correlation change, in turn, having a certain relationship with the level of per capita income of the country.

So, in the first place, future growth rate of GNP in each of the subject countries is estimated.

Then, the coefficient of the correlation, the elasticity of rubber products demand to GNP, is estimated. For this estimation, the relationships among level of per capita income, growth rate of GNP and the elasticity value for each product experienced in Japan in the past are applied as shown in Table II-3. As shown in Table II-3, the elasticity value of tire demand in Japan through the 1950's and 1960's are very high and this is related to her high growth rate of GNP. In almost all of the subject countries, level of per capita income is lower than $1,000 and their GNP growth rates are lower than that of Japan in the past. Where such is the case, the elasticity value is applied after a certain adjustment. For countries where per capita income exceeds $3,000, elasticities in the United States are applied.

Table II-3 GNP Elasticities of Demand for Rubber Products

Per Capita Income Level ($)	Year	Annual Average GNP Increase Rate (%)	Elasticities		
			Passenger Car Tire	Truck and Bus Tire	Non-tire Products
250	1955				
300	1958	11	2.55	2.10	1.56
400	1960				
500	1962				
750	1965	11	2.64	2.27	1.55
1,000	1967				
1,700	1970	10	2.4	0.8	1.2
2,000	1972		1.7		
3,000	1965				
4,000	1970		1.0	0.8	1.2
5,000	1972				

c. Prospective Sales of SBR and BR produced in Kuwait

The demands thus calculated for each country are total demand, so it is not possible to expect that all of these demands are fulfilled by the SBR and BR produced in Kuwait. Therefore, prospective sales of

Kuwaiti-made SBR and BR are estimated. This estimation is made taking mainly the following factors in each country into consideration:

1. Competition with synthetic rubbers produced in the countries other than Kuwait, especially in the country itself. The existing and planned production facilities in neighbouring countries are shown in Table II-4.
2. Competition with natural rubber, which will be discussed below
3. Price
4. Present shares of existing synthetic rubber manufacturers

Table II-4 Synthetic Rubber Production Projects in Kuwait's Neighbouring Countries

	Product	Capacity(T/Y)	Start-up Schedule
Iran	SBR	40,000	1978
Turkey	SBR	32,000	On-stream
	BR	13,000	Under construction
Egypt	SBR	80,000	1980
Algeria	SBR	52,000	1978
	BR	30,000	1978
Yugoslavia	SBR	40,000	1979
India	SBR	30,000	On-stream
	BR	20,000	1977

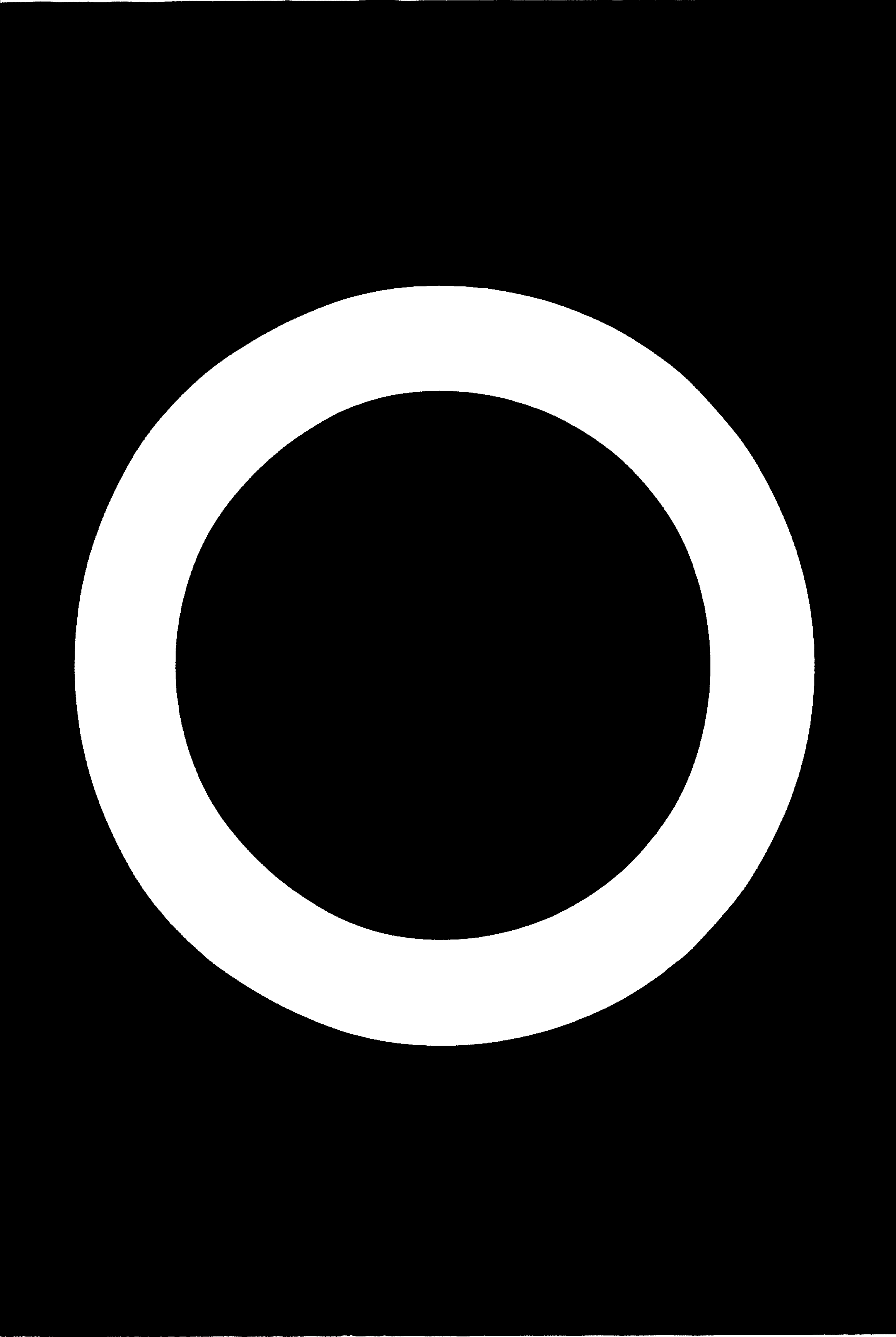
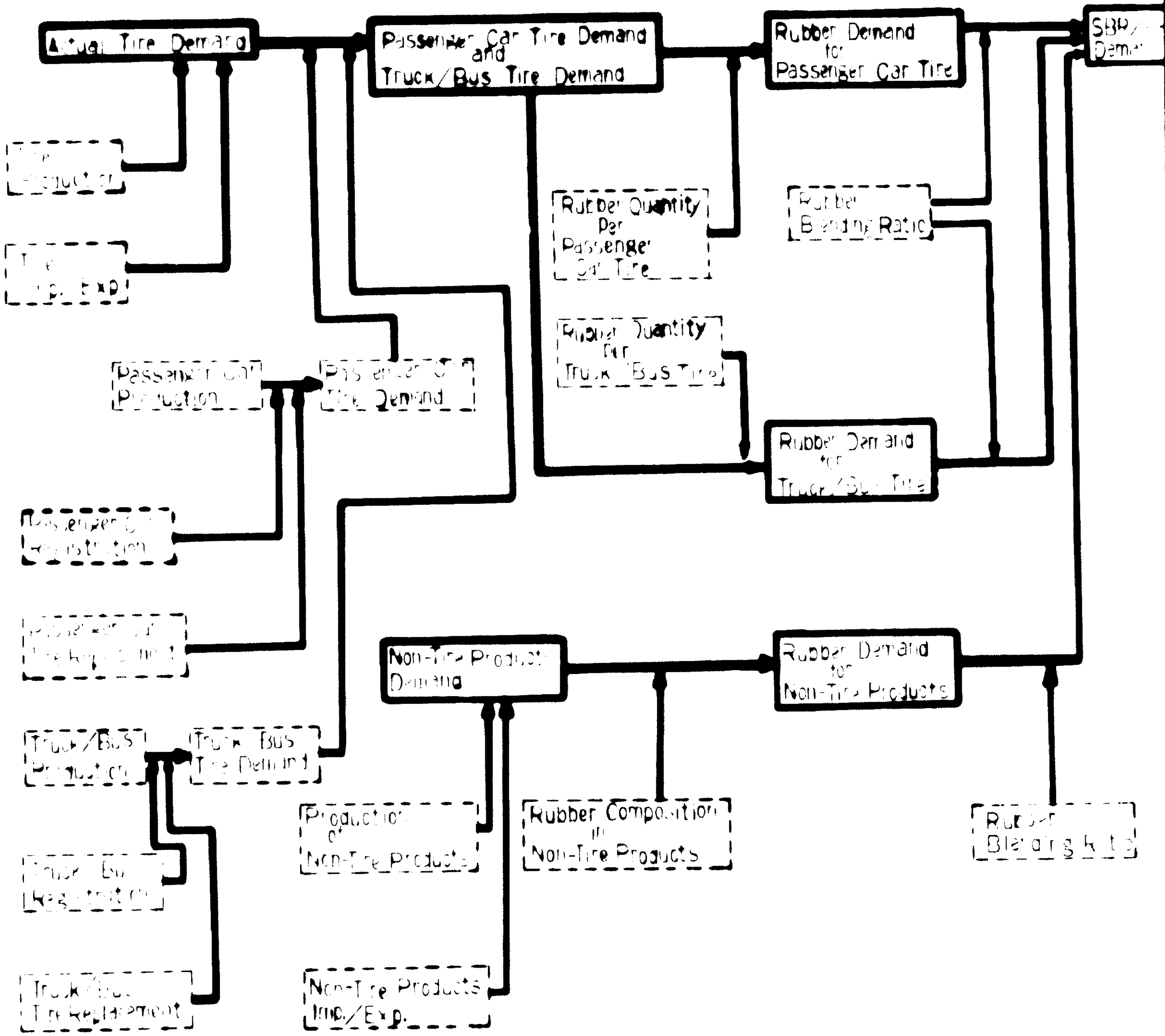
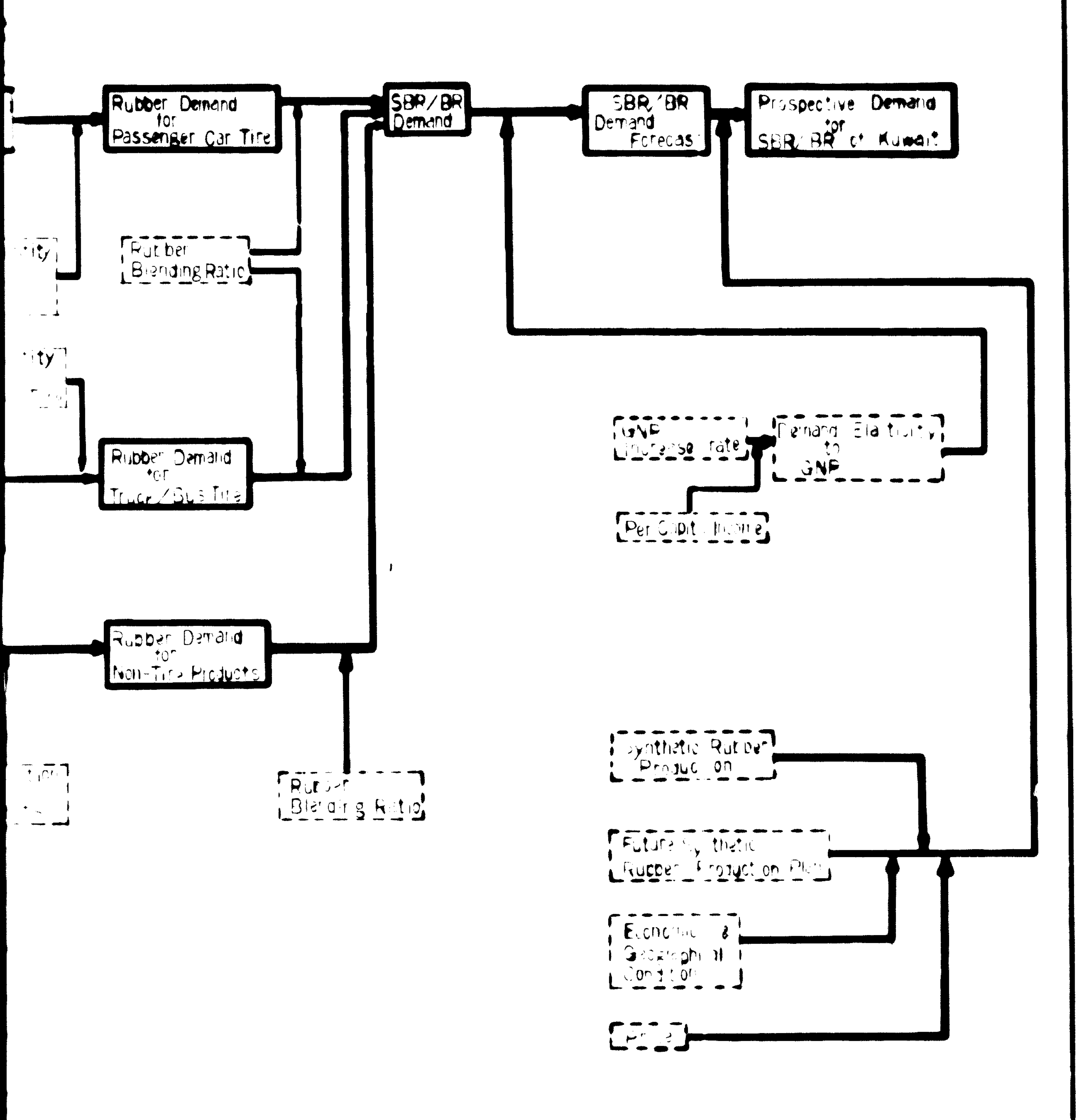


Fig.II-1 Methodology of Demand Forec...



Methodology of Demand Forecast



Supplementary Discussion on Natural Rubber

a. **Availability**

World production and consumption of natural rubber are shown in Table II-5, and Table II-6 gives the natural rubber production by country in 1974.

Table II-5 World Production and Consumption of Natural Rubber (1964 - 1974)

(in 1,000 tons)

Year	Production	Consumption
1964	2,332.5	2,300.0
1965	2,332.5	2,447.5
1966	2,392.5	2,548.5
1967	2,582.5	2,535.0
1968	2,685.0	2,780.0
1969	2,995.0	2,910.0
1970	3,108.5	2,998.5
1971	3,085.0	3,095.0
1972	3,185.0	3,235.0
1973	3,518.5	3,410.0
1974	3,475.0	3,380.5

Table II-6 Natural Rubber Production in 1974

Country	Production (in 1,000 tons)	Component Ratio (%)
Malaysia	1,549	44.6
Indonesia	880	25.3
Thailand	380	10.9
Sri Lanka	132	3.8
India	128	3.7
Africa	242	7.0
South & Central America	37	1.1
Others	127	3.6
TOTAL	3,473	100.0

Both production and consumption of natural rubber in the world have grown with an average annual rate of 6% over the past decade. In each of the ten years, no significant gap was seen between the output and use. About 90 percent of the world natural rubber is supplied by Asian countries and the rest comes from such African nations as Liberia, Nigeria and Zaire and Latin American countries such as Brazil.

As natural rubber is an agricultural product, it is not easy to increase its production rapidly.

A few countries such as Malaysia and Brazil have been making efforts to raise productivity—by switching-over to superior plants, fertilization, use of ethrel (latex flow stimulant)—but improvement in short period would not be expected. Expansion of a rubber plantation cannot readily lead to a corresponding increase in output, because it takes 5-6 years from planting of rubber trees before they can be tapped. Other adverse factors include delays in the integration of rubber processing facilities and product distribution systems, and in the improvement of related infrastructure such as roads, port facilities, etc.

In view of the above, any sharp increase in natural rubber production is not conceivable, at least for the near future, annual growth rate being about 4%.

b. <u>Characteristics of Demand</u>

In the manufacture of rubber products, synthetic rubber and natural rubber are blended at a specified ratio in order to maintain constant quality. So, in many cases, production facilities are built to meet specific conditions that would not allow ready modifications.

In particular, in the tire industry, it is usual that the rubber blending ratio, once established, could not be modified frequently in consideration of vehicular safety.

On the other hand, the output of natural rubber, being an agricultural product, is not stable and there is no definite assurance of constant supplies required by rubber products manufacturers.

Therefore, any increase in the blending ratio of natural rubber—while welcome to natural rubber producing countries—would prove not preferable to tire and other rubber product manufacturers.

Table II-7 World Rubber Consumption and Shares

	1965		1970		1974	
	in 1,000 tons	%	in 1,000 tons	%	in 1,000 tons	%
Synthetic Rubber	3,740	60	5,685	65	7,270	67
Natural Rubber	2,447	40	2,932	35	3,528	33
TOTAL	6,187	100	8,617	100	10,798	100

As shown in Table II-7, the share of natural rubber consumption in the total rubber use of the world is on the decrease. Even though this decreasing rate could decelerate in the future, it would be unlikely that the share of natural rubber could make a sharp recovery.

c. Instability of Prices

Natural rubber and general purpose rubber are used alternatively in manufacture of tire and other rubber products to a considerable extent.

For rubber products manufacturers, the stability of rubber price is as much a matter of concern as the stable supply. In this respect, natural rubber again is in a inferior position to synthetic rubber.

Natural rubber price has shown significant fluctuations in the past, while prices of synthetic rubber had always been running below natural rubber prices, thereby expanding the share of synthetic rubber.

Table II-8 gives the price fluctuation of natural rubber in recent years.

Table II-8 Price Fluctuation of Natural Rubber

(Annual Average Price)

Year	Price (in U.S. cents/kg)
1972	40
1973	78
1974	83
1975	63

The figures given in Table II-8 are annual average prices and do not reflect a large fluctuation within the year. For instance, in December 1973, the natural rubber price rose as high as $1/kg because of worldwide supply crisis.

d) <u>Results of Market Study</u>

Table II-9 shows the demand forecast of each country and its prospective demands for SBR and BR produced in Kuwait in 1980 through 1990 based on the above Methodology of Demand Forecast.

As for studies on the market in each country, explanations are given in the following "(2) Domestic Market" and "(3) Export Market".

	1976		1980		1981		1982	
	SBR	BR	SBR	BR	SBR	BR	SBR	BR
Kuwait								
Demand Forecast	2,200	700	3,200	900	3,600	1,000	3,900	1,100
Prospective Demand			3,200	900	3,600	1,000	3,900	1,100
Iran								
Demand Forecast	23,300	3,300	63,000	12,100	69,100	13,400	76,100	14,700
Prospective Demand			-	6,100	-	6,700	-	7,900
Iraq								
Demand Forecast	3,300	600	3,600	1,000	6,300	1,200	7,000	1,300
Prospective Demand			1,900	500	2,100	600	2,300	700
Syria								
Demand Forecast	2,900	400	5,100	800	5,600	800	6,300	1,000
Prospective Demand			1,700	400	1,900	400	2,100	500
Saudi-Arabia								
Demand Forecast	5,100	1,400	11,000	3,100	12,300	3,400	14,000	3,900
Prospective Demand			3,700	1,600	4,100	1,700	4,700	2,000
Egypt								
Demand Forecast	3,400	1,600	6,600	3,300	7,600	3,900	8,700	4,300
Prospective Demand			-	1,100	-	1,300	-	1,500
Libya								
Demand Forecast	3,000	1,000	5,400	2,000	6,100	2,200	6,900	2,600
Prospective Demand			1,400	700	1,500	700	1,700	900
Sudan								
Demand Forecast	2,200	600	4,100	1,100	4,600	1,300	5,000	1,400
Prospective Demand			1,000	400	1,100	400	1,300	500
Tunisia								
Demand Forecast	3,000	900	4,700	1,500	5,200	1,700	5,600	1,800
Prospective Demand			1,200	500	1,300	600	1,400	600
Algeria								
Demand Forecast	4,600	600	10,500	1,400	12,000	1,700	13,600	1,900
Prospective Demand			-	-	-	-	-	-
Morocco								
Demand Forecast	6,000	900	10,400	1,700	11,500	1,800	12,700	2,000
Prospective Demand			2,100	600	2,900	600	3,200	700
Yugoslavia								
Demand Forecast	42,300	9,600	57,200	13,100	60,800	14,100	64,500	15,000
Prospective Demand			-	1,200	-	1,500	-	1,800
Greece								
Demand Forecast	7,700	800	12,500	1,500	13,700	1,700	14,900	1,900
Prospective Demand			3,100	500	3,400	600	3,700	600
Turkey								
Demand Forecast	23,700	900	35,900	7,000	38,600	7,500	41,500	8,100
Prospective Demand			-	-	-	-	-	-
Pakistan								
Demand Forecast	2,400	1,200	4,000	2,200	4,400	2,500	4,700	2,700
Prospective Demand			1,000	700	1,100	800	1,200	900
India								
Demand Forecast	30,000	1,000	59,600	8,400	68,400	12,900	78,400	19,700
Prospective Demand			-	-	-	-	-	-
East Africa								
Demand Forecast	3,000	1,400	8,600	2,400	9,600	2,700	10,700	3,000
Prospective Demand			2,200	800	2,400	900	2,700	1,000
Total Demand Forecast	170,500	29,100	307,400	63,500	339,400	73,800	374,500	86,600
Total Prospective Demand			22,500	16,000	25,400	17,800	28,200	20,700

SECTION 1

II-9 Results of Market Study

	1982		1983		1984		1985		1990	
	SBR	BR	SBR	BR	SBR	BR	SBR	BR	SBR	BR
)	3.900	1.100	4.200	1,200	4,600	1,200	4.900	1,400	7,500	2,100
)	3.900	1.100	4.200	1.200	4,600	1,200	4.900	1,400	7,500	2,100
)	76.100	14.700	83.600	16,300	91,900	17,900	101.100	19,900	162,500	32,600
)	-	7.900	-	8,200	-	9.000	-	10,000	-	16,300
)	7.000	1.300	7,700	1,400	8.600	1,600	9.500	1,800	15,300	3,000
)	2.300	700	2.600	700	2.900	800	3.200	900	5,100	1,500
)	6.300	1.000	6,900	1,000	7,700	1.200	8,600	1,300	13,900	2,300
)	2.100	500	2,300	500	2,600	600	2,900	700	4,600	1,200
)	14,000	3.900	15.800	4.400	18.100	5.000	20,300	5,700	37.400	10,700
)	4.700	2,000	5,300	2,200	6,000	2,500	6,800	2,900	12,500	5,400
)	8,700	4,500	9.800	5.200	11,400	6,000	13,100	7,000	26,400	14,700
)	-	1.500	-	1.700	-	2,000	-	2,300	-	4,900
)	6.900	2.600	7.700	2.900	8,700	3,400	9.900	3,800	14,200	5,400
)	1.700	900	1,900	1.000	2.200	1,100	2.500	1,300	3,600	1,800
)	5.000	1,400	5.700	1,600	6,300	1,800	7,000	2,000	12,200	3,600
)	1.300	500	1.400	500	1.600	600	1.800	700	3,000	1,200
)	5,600	1,800	6,200	2.100	6,700	2,300	7,400	2,400	11,400	3,800
)	1.400	600	1,500	700	1,700	800	1,800	800	2,800	1,300
)	13.600	1,900	15.600	2.300	17,700	2.700	20,200	3,200	32,200	5,800
	-	-	-	-	-	-	-	-	-	-
)	12,700	2.000	14,100	2.200	15.500	2.500	17,100	2,700	28,100	4,500
)	3,200	700	3.500	700	3,900	800	4,300	900	7,000	1,500
)	64.500	15,000	68,500	15,900	72,800	16,900	77,300	18,000	104,200	24,900
)	-	1,800	-	2,100	-	2 400	-	2,800	-	5,100
)	14,900	1.900	16,500	2,300	18.100	2.600	19 800	2,900	28,000	4,000
)	3,700	600	4.100	800	4.500	900	4,900	1,000	7,000	1,300
)	41.500	8.100	44,500	8,700	47,900	9,400	51.600	10,000	71,800	14,400
	-	-	-	-	-	-	-	-	-	-
)	4,700	2,700	5,100	3,000	5,600	3,400	6.200	3,800	9,600	6,300
)	1,200	900	1,300	1,000	1,400	1,100	1,500	1,300	2,400	2,100
)	78,400	19,700	90,000	30,000	97,200	32,400	105,000	35,000	147,300	49,100
	-	-	-	-	-	-	-	-	-	-
)	10,700	3,000	11,900	3,300	13,200	3,700	14,700	4,100	25,200	7,000
)	2,700	1,000	3,000	1,100	3,300	1,200	3,700	1,400	6,300	2,300
)	374,500	86,600	413,800	103,800	452,000	114,000	493,700	25,000	747,200	194,200
)	28,200	20,700	31,100	22,400	34,700	25,000	38,300	28,400	61,800	48,000

SECTION 2

(2) Domestic Market

a) Demand for Tires and Non-Tire Products

Table II-10 Demand for Tires and Non-Tire Products in Kuwait

(Tons/Year)

		1972	1973	1974
Tires	Import	7,566	7,896	10,200
	Export	1,131	1,120	1,776
	Demand	6,435	6,776	8,424
Non-Tire Products	Import	803	823	1,658
	Export	88	189	548
	Demand	715	634	1,110

b) Tire Manufacturers in Kuwait

No tire manufacturing industry exists in Kuwait at present.

National Industries Co., which obtained a license from the Government of Kuwait for tire production, is expediting preparations to launch a construction project of a 13,000 t/y tire manufacturing company in 1976 there, whose startup is scheduled for 1978.

c) <u>Demand Forecast for SBR and BR</u>

Kuwait's per capita income in 1975 was as large as about $5,000. Kuwait's real annual GDP growth rate during the period of the First Five-Year Economic Development Plan (1967/68-1971/72) was about 6.9% on the average. It is presumed that Kuwait's GDP growth has thereafter been attained and will continue at almost the same real annual rate.

Our presumption of the annual growth rate of rubber products demand in Kuwait is as follows:
Persons per passenger car in Kuwait is 6. Since the number of passenger cars in Kuwait is expected to increase in the future at about the same rate as its GDP, an annual increase rate of passenger cars hereafter is set at 6.9%, the same rate is applied to the annual growth rate of passenger car tires.

Persons per truck and bus in Kuwait as of 1975 is 20, which number is expected to decrease as the industrialisation of Kuwait makes progress.

Thus, an annual increase in demand for tires for truck and bus, which will be higher than that for passenger car tires, is set at 10%.

As Kuwait's manufacturing industries are expected to greatly develop in the future, demand for non-tire products will also increase substantially, whose annual increase rate, therefore, is set at 10%.

On the above basis, the demand forecast for SBR and BR is estimated.

(3) Export Market

a) Iran

a. Demand for Tires and Non-Tire Products

Table II-11 Demand for Tires and Non-Tire Products in Iran

(Tons)

		1973/74	1974/75
Tires	Production	25,300	33,000
	Import	25,600	31,100
	Export	400	0
	Demand	50,500	64,100
Non-Tire Products	Production	2,300	14,200
	Import	4,400	5,700
	Export	0	0
	Demand	6,700	19,900

b. Tires and Non-Tire Products Manufacturers in Iran

Iran's present tire manufacturers are as follows:

B.F. Goodrich Iran

Production capacity: 20,000 Tons/Y

Production in 1974: 15,000 Tons

The General Tire & Rubber Company of Iran

Production capacity: 20,000 Tons/Y

Production in 1974: 18,000 Tons

Bridgestone Tire Co. of Iran

Production capacity: 20,000 Tons/Y

It has launched tire production in 1976.

Industrie Pirelli spa of Italy has obtained a license to construct a 40,000 t/y tire production factory in Iran, which is scheduled to start up in 1978 or 1979.

As for non-tire products manufacturers of Iran, there are some manufacturers of shoes, floor sheets for cars, hoses, etc.

c. <u>Demand Forecast for SBR and BR</u>

Under its Fourth Five-Year Economic Development Plan (1968/69-72/73), Iran attained an average annual GNP growth rate of 11.8%. By the Fifth Five-Year Economic Development Plan from March 1973 through March 1978, Iran is aiming to achieve an annual GNP growth rate of 11.4%.

In and after 1978, its annual GNP growth, even if somewhat slowed down, is expected to record an increase of 7-9%.

During the decade 1963-1972, Iran's per capita income showed a remarkable increase from $200 to $530. By 1978 when the Fifth Five-Year Economic Development Plan will be completed, Iran's per capita income will increase up to $850.

Thus, Iran's future annual growth rates of rubber products demand are forecasted as shown in Table II-12.

Table II-12 Annual Growth Rates of Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	27.5	9.8	9.8
Truck & Bus Tires	17	11.2	11.2
Non-Tire Products	15.9	8.4	8.4

d. Prospective Demand for SBR and BR produced in Kuwait

Iran-Japan Petrochemical Co. is planning to construct a petrochemical complex in Bandar Shahpur based on 300,000 t/y ethylene production. This complex is planned to involve a 40,000 t/y SBR plant. With demand for SBR increasing in Iran, future expansion of this SBR plant is conceivable. In the circumstances, therefore, Iran will not make a good market for SBR to be produced in Kuwait. However, as Iran so far has no BR production programme and it has to import BR from Japan, Europe and other countries, it is possible to expect that Iran, being nearer to Kuwait, could turn to Kuwait for about one-half of its domestic needs for BR.

b) <u>Iraq</u>

a. <u>Demand for Tires and Non-Tire Products</u>

Table II-13 <u>Demand for Tires and Non-Tire Products in Iraq</u>

(Tons)

		1971	1972	1973
Tires	Import	5,100	5,300	8,700
	Export	0	0	0
	Demand	5,100	5,300	8,700
Non-Tire Products	Production	n.a.	n.a.	6,000
	Import	700	800	500
	Export	100	0	0
	Demand	n.a.	n.a.	6,500

b. <u>Tire and Non-Tire Products Manufacturers in Iraq</u>

There are no tire manufacturers in Iraq at present, but, Industrie Pirelli spa of Italy is building one on a turn-key basis. This plant is intended for a production capacity of 500,000 tires/year, and production start is slated for 1977. Besides this plant, the Iraqi Government has a plan in contemplation to build a plant for production of 700,000 radial tires/year.

There are several manufacturers, small in size, producing non-tire products. They used about 1,500 tons/year of SBR in 1975 as raw material.

c. <u>Demand Forecast for SBR and BR</u>

Real GNP growth rate has annually been about 7% in past several years in Iraq. It is presumed that Iraqi GNP growth will continue at the same real annual rate.

Per-capita income was about $480 in 1975. It will be expected to increase up to $680 in 1980. Iraq's future annual growth rates of rubber products demand are given in Table II-14.

Table II-14 <u>Annual Growth Rates of Rubber Products Demand</u>

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	11.2	11.2	11.2
Truck & Bus Tires	11.2	11.2	11.2
Non-Tire Products	9.1	10.5	8.6

d. <u>Prospective Demand for SBR and BR produced in Kuwait</u>

While there are some plans in Iraq to establish a petrochemical industry, there is no plan to establish a synthetic rubber industry. Iraq depends on imports from Japan, Europe and other countries for its requirements for SBR and BR. The prospective demand for SBR and BR produced in Kuwait is one-third and one-half respectively of Iraq's total domestic demand.

c) <u>Syria</u>

a. <u>Demand for Tires and Non-Tire Products</u>

Table II-13 Demand for Tires and Non-Tire Products

(Tons)

		1972	1973
Tires	Import	2,800	4,300
	Export	0	0
	Demand	2,800	4,300
Non-Tire Products	Production	n.a.	5,000
	Import	2,100	1,600
	Export	100	0
	Demand	n.a.	6,600

b. Tire and Non-Tire Products Manufacturers in Syria

There are no tire manufacturers in Syria at present. There is, however, a plan to set up one in Hama with Czech assistance. This plant, when finished, will have a production capacity of 600,000 tires/year. The plant is slated for starting operation in 1979.

There are several manufacturers of non-tire products. In 1973, they used a total of 1,000 tons/year of SBR as raw material.

c. **Demand Forecast for SBR and BR**

Syria's annual GNP growth rate from 1971 to 1975 was 8.2% on the average. After 1975, its annual GNP growth is expected to record also an annual increase of 8.2% until 1980 and an increase of 7% afterwards.

On this basis, the per-capita income in 1973 of $360 will increase to $620 in 1980 and $880 in 1985.

Table II-16 shows the estimated annual growth rates for rubber products demand after 1975.

Table II-16 Annual Growth Rates of Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	14.8	12.6	12.6
Truck & Bus Tires	13.9	11.9	11.9
Non-Tire Products	10.7	10.5	8.4

d. Prospective Demand for SBR and BR produced in Kuwait

No plan exists in Syria to develop a petrochemical industry. Consequently, Syria does have no plans to develop a synthetic rubber industry.

Syria depends on imports from European countries, Japan and other countries for its requirements for SBR and BR. Since Syria is not far from Kuwait geographically, and they both belong to the Arab community, Syria will be anticipated as a market for SBR and BR, one-third and one-half respectively of its total requirements.

d) Saudi-Arabia

a. Demand for Tires and Non-Tire Products

Since information about recent foreign trade of Saudi-Arabia is inavailable, it is necessary to depend on data concerning exports to Saudi-Arabia from other countries, according to foreign trade statistics of the United States of America, the United Kingdom, France, West Germany and Japan.

Table II-17 gives estimated demand for tires and non-tire products in Saudi-Arabia based on the information obtained from these non-Saudi-Arabian sources.

Table II-17 <u>Demand for Tires and Non-Tire Products</u>

(Tons)

	Demand	
	1973	1974
Tires	12,300	19,100
Non-Tire Products	3,500	2,800

b. <u>Tire Manufacturers in Saudi-Arabia</u>

There is no tire industry in Saudi-Arabia at present. However, the Second Five-Year Development Plan (1975--1979) includes a tire plant to be built in Jiddah. The plan requires an annual production of 3,000,000 tires. This goal may be difficult to be achieved, but it is possible to establish a tire factory of 2,000,000 tires/year production by 1980 when the Second Five-Year Plan completes.

c. <u>Demand Forecast for SBR and BR</u>

According to the Second Five-Year Development Plan, Saudi-Arabia is aiming to achieve an annual GNP growth rate of 10.2%. After 1980, its annual GNP growth is expected to record an increase of 8%. Accordingly, the per capita income in 1975 of $400 will increase to $660 in 1980 and $970 in 1985. Table II-18 shows the annual growth rates for rubber products demand, calculated based on the above GNP growth rate.

Table II-18 Annual Growth Rates for Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	18.4	14.4	14.4
Truck & Bus Tires	16.8	13.2	13.2
Non-Tire Products	14.3	12.0	9.6

d. Prospective Demand for SBR and BR produced in Kuwait

In the Second Five-Year Development Plan, Saudi-Arabia is planning to construct four petrochemical complexes (three in the eastern region and one in the western region), each with a capacity of 500,000 tons/year of ethylene.

However, the four petrochemical complexes may not include any synthetic rubber plant.

Saudi-Arabia, being a neighboring country of Kuwait, may import SBR and BR from Kuwait up to one-third and one-half respectively of the total domestic demand.

e) Egypt

a. Demand for Tires and Non-Tire Products

Table II-19 Demand for Tires and Non-Tire Products

		1971	1972	1973	1974	1975
Tires (Pieces/Y)	Production					
	Passenger car	268,000	300,000	n.a.	160,000	310,000
	Truck & Bus	160,000	170,000	n.a.	80,000	160,000
	Import	n.a.	n.a.	n.a.	n.a.	95,000
	Export	n.a.	n.a.	n.a.	n.a.	Neg.
	Demand	n.a.	n.a.	n.a.	n.a.	565,000
Non-Tire Products (T/Y)	Production	n.a.	n.a.	n.a.	n.a.	10,800
	Import	2,800	1,400	1,500	n.a.	1,000
	Export	-	-	-	n.a.	Neg.
	Demand	n.a.	n.a.	n.a.	n.a.	11,000

b. Tire and Non-Tire Products Manufacturers

Transport & Engineering Co. is Egypt's sole tire manufacturer, of which tire production is not enough to fulfill its domestic demands. So the manufacturer plans to double the current production capacity by 1980.

For non-tire products, there are El Nasr Co. for Rubber Products, the country's biggest rubber producer, and several small shoe sole manufacturers.

Transport & Engineering Co.	Tires
Production in 1975	470,000 pieces/Y
El Nasr Co. for Rubber Products	Non-Tire Products
Production in 1975	5,000 T/Y

c. Demand Forecast for SBR and BR

The country's real GNP growth rate over the past several years is less than 9% per year. As a guideline for the future, 7% growth rate in view of its New Five-Year Project under preparation could be expected, though the target growth rate has not yet been announced.

Based on the 7% growth rate Egypt's per capita income which was $270 in 1975 will rise to $730 in 1990. Estimated annual growth rates for tire and non-tire products demand are given in Table II-20.

Table 11-20 Annual Growth Rates for Rubber Products Demand

	Growth Rates(%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	18	18	17
Truck & Bus Tires	15	16	16
Non-Tire Products	10	11	11

d. Prospective Demand for SBR and BR produced in Kuwait

Egypt has a plan calling for construction of a petrochemical complex in Alexandria with scheduled startup in 1980. The plan includes production of 80,000 T/Y of SBR. The quantity is expected to far exceed in 1980 the anticipated demand for SBR in the Egyptian market.

The balance will be a negative factor for Kuwait in its SBR export to Egypt. However, Egypt could use Kuwait-produced BR up to about one-third of its total domestic demands.

f) Libya

a. Demand for Tires and Non-Tire Products

Table II-21 Demand for Tires and Non-Tire Products

		1970	1972
Tires (Pieces/Y)	Production	0	0*
	Import	41,000	243,000
	Export	0	0
	Demand	41,000	243,000
Non-Tire Products (T/Y)	Production	n.a.	750
	Import	n.a.	1,700
	Export	n.a.	0
	Demand	n.a.	2,450

*) From its synthetic rubber imports, it is presumed that Libya had not yet gone into tire production as of 1970 and 1972.

b. Tire and Non-Tire Products Manufacturers

Libya's present sole tire manufacturer is Firestone, and its non-tire products manufacturers are a few and small sized.

Firestone

Production Capacity n.a.

c. Demand Forecast for SBR and BR

Libya's real annual GNP growth rate during the period 1960-1973 was as high as 17% on the average and its per capita income in 1972 was $1,900, the second largest among the Arab countries next to Kuwait.

Under the 1973-1975 Three-Year Plan, its average annual GNP growth rate was set at 11%. Its subsequent annual growth rate is estimated at 7%, and if this annual growth rate is successfully attained, Libya's per capita income in 1990 will amount to $7,000.

With respect to demand for tires, the number of persons per passenger car and that for truck and bus are 22 and 48 respectively, which are close to those of developed nations. Therefore, elasticity coefficients of rubber products demand to GNP will be smaller than those for its neighboring Arab countries.

Table II-22 Annual Growth Rates of Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	12	7	7
Truck & Bus Tires	15	16	7
Non-Tire Products	10	11	8

d. Prospective Demand for SBR and BR produced in Kuwait

Libya has no plan to produce synthetic rubber domestically, and is now importing all synthetic rubber requirements from European countries.

In consideration of synthetic rubber industrialisation plans of Egypt and Algeria, Kuwait will find a market for its SBR and BR in one-fourth and one-third of total SBR and BR demands in Libya respectively.

g) Sudan

a. Demand for Tires and Non-Tire Products

Table II-23 Demand for Tires and Non-Tire Products

		1969	1970	1971
Tires (Pieces/Y)	Production	0	0	0
	Import	125,000	82,000	234,000
	Export	0	0	0
	Demand	125,000	82,000	234,000
Non-Tire Products (T/Y)	Production	n.a.	n.a.	2,500*
	Import	n.a.	n.a.	470
	Export	n.a.	n.a.	0
	Demand	n.a.	n.a.	2,970

*) In 1971,682 T/Y of synthetic rubber was imported. It is believed that all of the imports are for raw material for non-tire products because tire is not produced domestically at that time.

The figure of 2,500 T/Y was obtained on the assumption that synthetic rubber would account for [illegible] of non-tire products.

b. <u>Tire and Non-Tire Products Manufacturers</u>

There is no tire manufacturer in Sudan. On the other hand, it is assumed that there will be several non-tire products manufacturers because of the import of 682 T/Y synthetic rubber in 1971.

c. <u>Demand Forecast for SBR and BR</u>

Sudan's real annual GNP growth rate from 1970 to 1975 was an average 8.1%. The subsequent growth rate is assumed to be 7%. On this basis, the per capita income in 1971 of $130 will increase to $190 in 1975 and $510 in 1990.

Table II-24 shows the annual growth rate for rubber products demand after 1975, calculated on the basis of the above GNP growth rate.

Table II-24 Annual Growth Rates for Rubber Products Demand

	Growth Rates(%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	18	13	13
Truck & Bus Tires	15	12	12
Non-Tire Products	10	10	11

d. Prospective Demand for SBR and BR produced in Kuwait

Same as the example of Libya, coefficients adopted in calculating the prospective demand for SBR and BR expectable for Kuwait are one-fouth and one-third respectively, of Sudan's total domestic demand.

h) Tunisia

a. Demand for Tires and Non-Tire Products

Table II-25 Demand for Tires and Non-Tire Products

		1971
Tires (Pieces/Y)	Production	n.a.
	Import	n.a.
	Export	n.a.
	Demand	267,000*

Non-Tire Products (T/Y)	Production	3,[illegible]
	Import	3,[illegible]
	Export	[illegible]
	Demand	[illegible],[illegible]

*) Statistical data is not available on tire demands, so estimation is based on car registrations.

b. <u>Tire and Non-Tire Products Manufacturers</u>

Firestone Co. is Tunisia's sole tire manufacturer. However, data on the firm's production capacity is not available.

c. <u>Demand Forecast for SBR and BR</u>

GDP growth rate per year was 6.9% from 1969 until 1972, and is announced to be 6.9% from 1973 until 1976. Growth rate in later years is assumed to be 6%.

On the basis of the above growth rate, the per capita income of $430 in 1973 will rise to $490 in 1975 and $1,200 in 1990. Annual growth rates for rubber products demand are estimated in Table II-26.

Table II-26 Annual Growth Rates for Rubber Products Demand

	Growth Rates(%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	9	9	9
Truck & Bus Tires	10	10	10
Non-Tire Products	8	8	8

d. Prospective Demand for SBR and BR produced in Kuwait

Same as the example of Sudan, Kuwait will find a market for its SBR and BR in one-fourth and one-third, respectively, of total SBR and BR demands in Tunisia.

i) Algeria

a. Demand for Tire and Non-Tire Products

Table II-27 Demand for Tire and Non-Tire Products

		1970	1972	1973
Tire		n.a.	n.a.	n.a.*
Non-Tire Products (T/Y)	Production	n.a.	n.a.	n.a.
	Import	5,135	5,088	6,349
	Export	neg.	neg.	neg.
	Demand	5,135	5,088	6,349

*) Data on tire demand in Algeria is not available, while the data below have been obtained on its rubber imports. We have estimated the quantity of synthetic rubber used for tires by deducting the quantity used for non-tire products from the quantity of rubber import below:

(T/Y)

Import of Rubbers	1970	1972	1973
Natural Rubber	2,607	3,000	2,052
Synthetic Rubber	2,657	4,350	3,196
SBR	2,025	3,548	2,387
BR	347	480	499

b. Tire Manufacturers

Michelin of France is a sole tire manufacturer. However, data on the firm's production capacity is not available.

c. Demand Forecast for SBR and BR

Under its First Four-Year Economic Development Plan during the period 1970-1973, Algeria attained a real annual GNP growth of 7%.

Under the 1974-1977 Second Four-Year Economic Development Plan, Algeria's annual GNP growth rate is set at 10%, and that for subsequent years is assumed to be 7%.

Based on the above GNP growth rates, the annual growth rates of rubber products demand are estimated as shown in Table II-28. Meanwhile, Algeria's per capita income was $300 in 1970 and $480 in 1975, and will amount to $1,300 in 1990.

Table II-28 Annual Growth Rates of Rubber Products Demand

	Growth Rate (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	18	18	13
Truck & Bus Tires	18	18	13
Non-Tire Products	14	14	10

d. Prospective Demand for SBR and BR produced in Kuwait

Algeria has plans to go into production of 52,000 tons/year of SBR and 30,000 tons/year of BR in 1978.

These quantities are sufficient to fulfill domestic demands for SBR and BR in Algeria.

Therefore, Kuwait will have no chance to export its SBR and BR to Algeria.

j) Morocco

a. Demand for Tires and Non-Tire Products

Table 11-29 Demand for Tires and Non-Tire Products

		1970
Tires (Pieces/Y)	Production	410,000
	Import	98,000
	Export	0
	Demand	508,000
Non-Tire Products (T/Y)	Production	4,000
	Import	2,800
	Export	0
	Demand	6,800

b. Tire and Non-Tire Products Manufacturers

Morocco's present tire manufacturers are as follows:

Goodyear

General Tire

But data on production capacity of these companies are not available. As for non-tire products manufacturers there are several manufacturers of shoes, floor sheets for cars, hoses, etc.

c. <u>Demand Forecast for SBR and BR</u>

Under its Second Five-Year Economic Development Plan (1968-72), Morocco attained an average annual GNP growth rate of 5.7%. According to the Third Five-Year Economic Development Plan, Morocco is aiming to achieve an annual GNP growth rate of 7.8%. After 1979, its GNP growth rate is expected to record 7%.

Based on these estimates, future annual growth rates of rubber products demand are given in Table II-30. Meanwhile, per capita income in 1970 of $280 will rise to $310 in 1975 and $890 in 1990.

Table II-30 <u>Annual Growth Rates for Rubber Products Demand</u>

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	14	13	12
Truck & Bus Tires	11	10	10
Non-Tire Products	11	10	8

d. **Prospective Demand for SBR and BR produced in Kuwait**

There is no plan to produce synthetic rubber domestically. However, in view of the synthetic rubber production projects in neighbouring countries and of the anticipated effort for export by European synthetic rubber producers the chance for Kuwait to sell its SBR and BR to this country will be limited to one-fourth and one-third respectively of its total domestic demand.

h) **Yugoslavia**

a. **Demand for Tires and Non-Tire Products**

Table II-31 **Demand for Tires and Non-Tire Products**

			1974
Tires (Pieces/Y)	Production	(Passenger Car)	2,500,000
		(Truck & Bus)	2,190,000
	Import	(P)	749,000
		(TB)	341,000
	Export	(P)	378,000
		(TB)	87,000
	Demand	(P)	2,871,000
		(TB)	2,444,000
Non-Tire Products (T/Y)	Demand		90,000*

c) Yugoslavia's synthetic rubber and natural rubber imports in 1974 were 49,000 and 32,000 tons respectively totalling 81,000 tons. Of this total, about 63,000 tons of synthetic and natural rubbers are presumed to have been used for tires.

Therefore, the remaining 18,000 tons/year would have been used for non-tire products, which was about 90,000 tons in terms of weight of products.

b. Tire and Non-Tire Manufacturers

Yugoslavia's present tire manufacturers are the following five companies:

	Rubber used for tire manufacture in 1974 (T/Y)
Borovo	18,500
Sava	28,500
Tigar	15,000
Record	6,500
Miloje Zakic	5,000

c. Demand Forecast for SBR and NR

Yugoslavia's real annual GNP growth rate during the period 1970-1973 was 4.7%, and that for 1975 and after is assumed to be 5%.

On this basis, Yugoslavia's per-capita income of $610 in 1972 has increased up to $730 in 1975 and is expected to amount to $1,500 in 1990.

The number of persons per passenger car in 1972 was 21, while that per truck and bus of the same year was as large as 166. Thus, Yugoslavia's annual growth rates for rubber products demand are as shown in Table II-32.

Table II-32 Annual Growth Rates for Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	5	5	5
Truck & Bus Tires	7	7	7
Non-Tire Products	6	6	5

4. Prospective Demand for SBR and BR produced in Kuwait

Yugoslavia plans to construct a 40,000 t/y SBR plant with its start-up scheduled for 1979.

However, our estimation indicates that Yugoslavia's demand for SBR will increase to 57,000 tons in 1980, leaving Yugoslavia 17,000 t/y short of SBR.

To meet this shortage, Yugoslavia could turn to the Soviet Union or other East European countries or expand its SBR plant. Such being the case, it will be difficult for Kuwait to find its SBR market in Yugoslavia.

It is also difficult for Kuwait to enter Yugoslavia's present BR market.

However, it will be possible for Kuwait to export its BR to Yugoslavia to meet about one-third of its new domestic needs for BR in the future.

1) Greece

a. Demand for Tires and Non-Tire Products

Table II-33 Demand for Tires and Non-Tire Products

		1972	1973	1974	1975
Tires (Pieces/T)	Production	n.a.	n.a.	n.a.	578,000
	Import	98,000	71,000	33,000	n.a.
	Export	8,000	9,000	n.a.	n.a.
	Demand	n.a.	n.a.	n.a.	578,000

Non-Tire Products (T/Y)	Production	11,000	13,000	n.a.	n.a.
	Import	0	0	n.a.	n.a.
	Export	0	0	n.a.	n.a.
	Demand	11,000	13,000	n.a.	n.a.

b. Tire and Non-Tire Products Manufacturers

Present tire manufacturers are as follows:

Goodyear Hellas S.A.I.C.

Production Capacity 330,000 pieces/year

Pirelli Hellas S.A.

Production Capacity 250,000 pieces/year

c. Demand Forecast for SBR and BR

Greece attained an remarkable average annual GNP growth rate of 11%. However, after 1975, its GNP growth rate is estimated to be 7%.

On the basis of the above growth rate, the per-capita income, $1,800 in 1973, will be $2,200 in 1975 and $6,000 in 1990.

Annual growth rates for rubber products demand are estimated in Table II-34.

Table II-34 **Annual Growth Rate for Rubber Products Demand**

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	9	9	10
Truck & Bus Tires	10	10	10
Non-Tire Products	8	8	8

d. **Prospective Demand for SBR and BR produced in Kuwait**

There is no plan to produce synthetic rubber domestically. In view of the plans to produce synthetic rubbers in neighboring countries and anticipated effort to export by European producers, the chances of Kuwait selling its SBR and BR to this country will be up to one-fourth and one-third respectively of its total domestic demands.

m) **Turkey**

a. **Demand for Tires and Non-Tire Products**

Table II-35 Demand for Tires and Non-Tire Products in Turkey

		1972	1973	1974
Tires for Passenger Car and Pick-up Truck (1,000 Pieces)	Production	946.2	1,109.9	1,215.6
	Import	132.1	218.3	684.0
	Export	22.7	36.4	68.7
	Demand	1,055.6	1,291.8	1,830.9
Tires for Truck and Bus (1,000 Pieces)	Production	752.4	837.6	835.7
	Import	10.2	66.3	53.8
	Export	1.3	1.1	2.8
	Demand	761.3	902.8	886.7
Non-Tire Products (1,000 Tons)	Production	n.a.	n.a.	28.0
	Import	n.a.	n.a.	1.5
	Export	n.a.	n.a.	0.1
	Demand	n.a.	n.a.	29.4

b. Tire Manufacturers in Turkey

There are three tire manufacturers in Turkey: Goodyear, Pirelli and Uni-Royal. Their annual output totals some 1.8 million tires.

Uni-Royal intends to expand its annual production capacity from the present 600,000 tires to 1.2 million. The Turkish Government has approved this plan. The Government has also granted a license to Lassa, new tire manufacturer, authorising it to build a tire manufacturing plant with a yearly production capacity of 1.2 million tires. Pethim's application to the Government to erect a tire plant to produce 1.2 million tires/year has not been approved yet.

The present production capacity of each manufacturer is as follows:

Goodyear	2,000 tires/day
Pirelli	2,200 tires/day
Uni-Royal	5,000 tires/day

c. <u>Demand Forecast for SBR and BR</u>

During the First Five-Year Development Plan (1963-1967) and the Second Five-Year Plan (1968-1972), the annual average rates of growth of GNP were around 6.7% and 6.9% respectively, both being less than the Plan's targets of 7%.

During the Third Five-Year Plan (1973-1977), Turkey is aiming to achieve an average annual growth rate of 8% in GNP.

After 1977, its annual GNP growth is expected to record an increase of 5-7%.

On this basis, the per capita income in 1975 of $500 will rise to $800 in 1980 and $1,000 in 1985.

Future annual growth rates of rubber products demand are given in Table II-36.

Table II-36 Annual Growth Rates of Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	12.5	8.0	8.0
Truck & Bus Tires	11.0	7.0	7.0
Non-Tire Products	12.0	7.5	6.0

4. Prospective Demand for SBR and BR Produced in Kuwait

In Yarimca, Kocaeli City, Turkey, there is a petrochemical complex run by Petrokimya A.S. The complex includes SBR and BR plants with production capacities of 32,000 tons/year and 13,000 tons/year respectively. The former is already in operation, but the latter is going to start production in the near future.

A second petrochemical complex is being planned for construction at the Izmir region with a capacity to produce 300,000 tons/year of ethylene. There is, however, no publication about synthetic rubber production.

Turkish Government has the policy to produce synthetic rubber within the country to meet all domestic demands, and there is no chance for Kuwait to export SBR and BR to Turkey.

e) <u>Pakistan</u>

a. <u>Demand for Tires and Non-Tire Products</u>

Table II-37 <u>Demand for Tires and Non-Tire Products</u>

		1973/74
Tires (1,000 Pieces)	Production	137
	Import	230
	Demand	367
Non-Tire Products (Tons)	Production	2,000
	Import	1,100
	Demand	3,100

b. <u>Tire and Non-Tire Products Manufacturers</u>

General Tire Co. is the only tire manufacturer in Pakistan. Its production capacity is about 300,000 pieces/year.

There are several non-tire products manufacturers, all small in size, consuming 1,200 tons of SBR in 1975.

c. <u>Demand Forecast for SBR and BR</u>

Real average annual GNP growth rate of Pakistan was 3.9% during the period from 1969/70 to 1973/74. During the Fifth Five-Year Plan (1975/76 - 1980/81), Pakistan is aiming to achieve an annual GNP growth rate of 9%. However, it may be impossible to increase GNP with such a high pace in view of the past low increase of GNP, and 6 or 7% will be expected.

Per capita income of Pakistan in 1974 was $110 and will be $200 in 1985.

Table II-38 shows the annual growth rates for rubber products demand.

Table II-38 Annual Growth Rates for Rubber Products Demand

	Growth Rates (%)		
	1975-1980	1980-1985	1985-1990
Passenger Car Tires	15.0	12.5	12.5
Truck & Bus Tires	13.2	11.0	11.0
Non-Tire Products	7.8	6.5	6.5

d. Prospective Demand for SBR and BR produced in Kuwait

In Pakistan there is no synthetic rubber industry nor plan for synthetic rubber production.

Pakistan depends on import mostly from Japan for its requirements of SBR and BR. Since Pakistan is not far from Kuwait and both countries have close economic relations with each other, it is expected that one-fourth and one-third of Pakistan's total demand for SBR and BR respectively will be met by export from Kuwait.

e) India

a. Indian Rubber Production and Demand

Table II-39 and Table II-40 show Indian Rubber Production and Indian Rubber Demand.

Table II-39 Indian Rubber Production

(1,000 tons)

	1971	1972	1973	1974
Natural Rubber	93.9	109.1	123.1	162.7
Synthetic Rubber	33.0	27.8	21.0	33.1

Table II-40 Indian Rubber Demand

(1,000 tons)

	1971	1972	1973	1974
Natural Rubber	93.1	101.1	120.7	145.6
Synthetic Rubber	36.7	37.1	25.2	32.7

As the above data explain, India is a major producer of natural rubber. The percentage of natural rubber used in rubber products produced in India is quite high. There may be a few exceptions, but India seems to have enough natural rubber and synthetic rubber produced locally to cover all its requirements.

b. Tire Manufacturers in India

There are seven tire manufacturers with nine factories in India.

Company	Installed Capacity (Unit: Pieces/year)	Additional Capacity	Total
Dunlop, Calcutta	867,200	30,000	1,167,200
Dunlop, Madras	380,000	-	380,000
Firestone, Bombay	672,000	-	672,000
Ceat, Bombay	650,000	-	650,000
Goodyear, Calcutta	600,000	-	600,000
Madras Rubber Factory (Mansfield, Madras)	610,000	390,000	1,000,000
Madras Rubber Factory (Mansfield, Goa)	400,000	-	400,000
Premier Tyres, Bombay	300,000	300,000	600,000
Incheck, Calcutta	300,000	400,000	700,000
	4,797,200	1,390,000	6,369,200

Five million tires were produced in 1974. Some of these manufacturers have been granted government licences authorising a plant expansion (as shown under "Additional Capacity" above). Products from these expanded manufacturing facilities will become available in 1979. The Indian government, to cope with increases in tire demand, is said to be ready to grant licences for further plant expansion programmes as well as to new tire manufacturers.

c. Demand Forecast for SBR and BR

India plans to increase car production in the Fifth Five Year Plan (1974/75--1978/79). The consequent rise in demand for tires will be met with the plan to increase tire production as shown in Table II-41.

Table II-41 Indian Fifth Plan Tire Output Targets

(1,000 pieces)

	1974/75	1975/76	1976/77	1977/78	1978/79
Motor Cycles	859	997	1,193	1,486	1,912
Jeeps	229	252	277	303	331
Cars	892	988	1,078	1,177	1,285
Commercial Vehicles	2,788	2,986	3,203	3,437	3,692
Defense Vehicles	258	305	328	352	400
Tractors, Trailers	391	446	513	592	683

Such increases in tire production will eventually increase demand for rubber. Natural rubber alone will not fill this rising demand because natural rubber, being an agricultural product, has a limited potentiality to increase production. The shortage will have to be covered by synthetic rubber. In other words, more synthetic rubber will be used in rubber products in India than natural rubber.

d. Prospective Demand for SBR and BR produced in Kuwait

There is a SBR plant with a production capacity of 30,000 tons/year in Bareilley, Uttar Pradesh State, India. With a view to fast increases in demand for SBR in India, an expansion of this plant is now being studied.

The Indian government has decided to build a BR plant of 20,000 tons/year capacity within the petrochemical complex in Gujarat State. The operation of this plant is slated for 1977.

India, as explained above, is moving in the direction of self-sufficiency in both SBR and BR. India, therefore, is not expected to import SBR and BR from Kuwait.

p) East African Countries

a. Synthetic Rubber Demand

Synthetic rubber demands in four East African countries in 1974 are presumed as shown in Table II-42.

Table II-42 Synthetic Rubber Demands

(Tons)

	SBR	BR
Kenya	1,300	650
Zambia	1,000	0
Tanzania	1,200	500
Ethiopia	1,000	100
Total	4,500	1,250

b. <u>Tire Manufacturers in East African Countries</u>

In four East African countries, there are four factories as follows:

Kenya	Firestone Tire
Zambia	Dunlop Tire
Tanzania	General Tire
Ethiopia	Addis Tire

c. <u>Demand Forecast for SBR and BR</u>

Average annual GNP growth rates of East African countries in past several years have been as follows: Kenya 6.9%, Zambia 6.4%, Tanzania 9.7%, Ethiopia 3.9%.

Per-capita incomes of East African countries in 1973 were as follows: Kenya $160, Zambia $410, Tanzania $180, Ethiopia $80.

Future annual growth of rubber products demand in East African countries is expected to record an increase of 11%.

d. <u>Prospective Demand for SBR and BR produced in Kuwait</u>

There is no synthetic rubber industry in East Africa.

which depends on imports from Japan, Europe and other countries for its requirements of SBR and BR.

Since East Africa is not far from Kuwait, the four countries can be expected as markets of SBR and BR from Kuwait up to the quantity equal to one-fourth and one-third respectively of their total demands.

(4) Price of Synthetic Rubber

Table II-43 provides approximate world selling prices of SBR and BR in recent years.

Table II-43 Approximate Selling Prices

(in U.S. cents/kg)

Year	SBR	BR
1972	35	38
1973	44	50
1974	80	87
1975	80	82

The notable price increase in 1974 is attributable to the price hikes of raw materials due to the so-called oil crises in late 1973, and other factors such as rises in plant investment cost, production cost, etc.

The price decline in 1975 was caused by the decrease of world SBR and BR demand due to economic stagnation worldwide. In the economic study of this report, the sales values of the product are calculated on the basis of constant unit price of 82 cents/kg in 1975.

Short range, the price of synthetic rubber is considerably affected by its supply-demand situation; but, longer range, it will be affected to a larger extent by the rise in cost.

Though it is very difficult to make a definite forecast of the future prices of synthetic rubbers, they are expected to continue rising inasmuch as both raw materials and production costs are likely to make continuing increases.

The cost of synthetic rubber can be divided into the following three components with their average percentage:

Raw material cost	40%
Plant investment cost	25%
Operating cost and others	35%

Discussion is given below as to the effects of these three cost factors on the increase of synthetic rubber prices. The assumptions made for this purpose are as follows:

For the raw material cost, it is assumed that this cost will equally affect all the products. Its annual increase is assumed to be 3%, 5% and 8% (three cases).

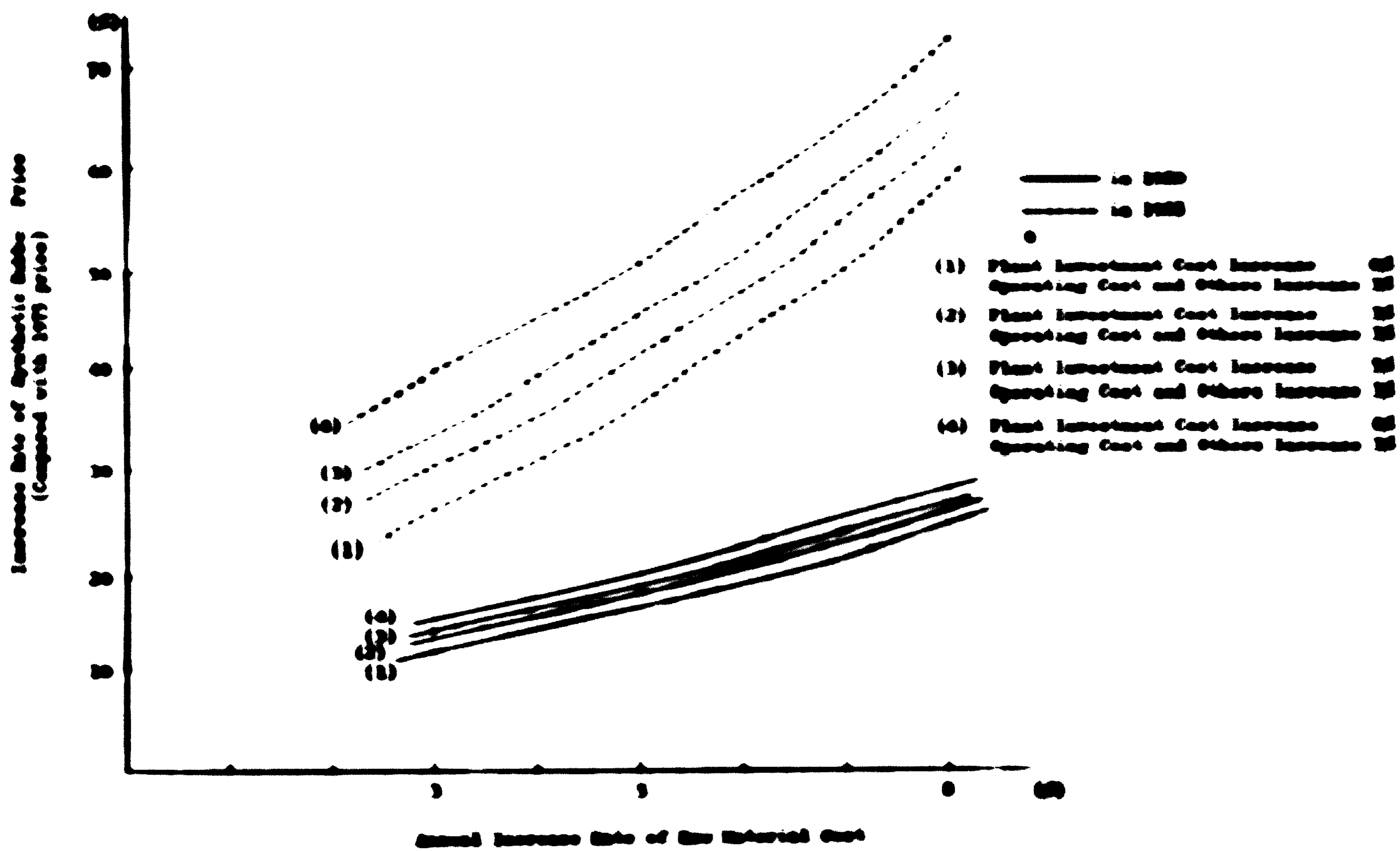
For the operating cost and others, the same assumption as above is made, with an annual rise of 3%.

For the plant investment cost, it is assumed that 10% of the yearly synthetic rubber output will be supplied by the new plant and that the synthetic rubber price of each year will be the weighted average of the cost of the synthetic rubber supplied within the year.

Yearly increase of this cost is assumed to be 0%, 3%, 5%, and 8% (four cases).

Fig. II-2 gives the effects on synthetic rubber prices of the various combinations of the above cost factors in 1980 and 1985.

Fig 11-2 Effects on Synthetic Rubber Prices of Cost Factors



II-8 Availability of Raw Materials

Essential raw material for the production of BR and SBR is butadiene. In the case of SBR production, styrene monomer is also necessary as a copolymer feedstock.

(1) Butadiene

Currently butadiene is manufactured as coproducts of ethylene production by naptha cracking or by dehydrogenation of butane or butene.

In Kuwait, Petrochemical Industries Company(PIC) has plans to produce ethylene by cracking of natural gas and around 7,000 tons per year of butadiene is expected to become available when the plan is materialised in 1980.

However, the plan is said to be not a firm one, and the quantity of butadiene, even if it becomes available, is not sufficient for the synthetic rubber production under consideration.

On the other hand, sufficient quantities of butadiene will be available in Kuwait by dehydrogenation of butane utilising an indigenous resource as feedstock.

At present, around 1.50 million tons per year of liquefied petroleum gases (LPG) is being separated from natural gas and further supply of LPG is expected by the end of the 1970's from a new LPG separation plant which is being constructed at the Shuaiba Industrial Area. The most portion of the LPG, as liquefied propane and butane, has been exported abroad, mainly to Japan, by the Ministry of Oil.

According to the Ministry of Oil, the butane will be readily supplied to the rubber plant at the current F.O.B. price, which is estimated to be 120 US$ per ton.

(2) Styrene Monomer

PIC has also plans to produce aromatics, in which a styrene monomer plant with a huge capacity is included.

However, as the plan is still not a firm one presently, import of around 10 thousand tons per year of styrene monomer (equivalent to 45,000 tons per year of SBR) should be considered if the above plan is not realised by the start-up of the SBR plant.

II-3 Other Considerations

On the basis of the prospective demand for SBR and BR produced in Kuwait as developed in the foregoing market study, a final selection of the products to be produced was made in consideration of the factors listed below:

(1) Characteristics of the synthetic rubber industry in Kuwait

(2) Minimum economical plant size of SBR and BR

(3) Availability of auxiliary raw materials, catalyst and chemicals

(4) Production management

(1) Characteristics of Industrialization for the Synthetic Rubber in Kuwait

As shown in Table II-4 many countries have their plans to produce SBR first as a general-purpose rubber.

Reasons for this could be that (1) SBR has much wider usage than BR and therefore, (2) Demand for SBR is bigger in domestic market than that for BR.

However, when these projects were realized as scheduled, these countries would have surplus SBR by the first half of the 1980's and have to find export markets because of limited domestic demand in their own countries.

On the other hand, the synthetic rubber industry in Kuwait should be export-oriented due to rather limited size of its domestic market.

In consideration of the above, it can be concluded that BR, which is expected to find prospective market in the neighbouring countries, should precede SBR in the development of the synthetic rubber industry in Kuwait.

(3) <u>Minimum Economical Plant Size</u>

The minimum economical production capacity of SBR is 40,000 T/Y and that of BR is 20,000 T/Y. On the other hand, the prospective demand for SBR and BR to be produced in Kuwait in 1981, as shown in the preceding Section II-1, is about 25,000 T/Y for SBR and 10,000 T/Y for BR.

Therefore, where the above minimum economical plant sizes are set for the Kuwaiti SBR and BR plants respectively, the operating factor of the BR plant at the start would be much higher than that of SBR.

(3) Availability of Auxiliary Raw Materials, Catalyst and Chemicals

SBR production requires styrene as feed in addition to butadiene, and the number of chemicals required for it is greater than for BR.

Inasmuch as all of these raw materials and chemicals will have to be imported, it should be advantageous to minimise the required number of raw materials and chemicals.

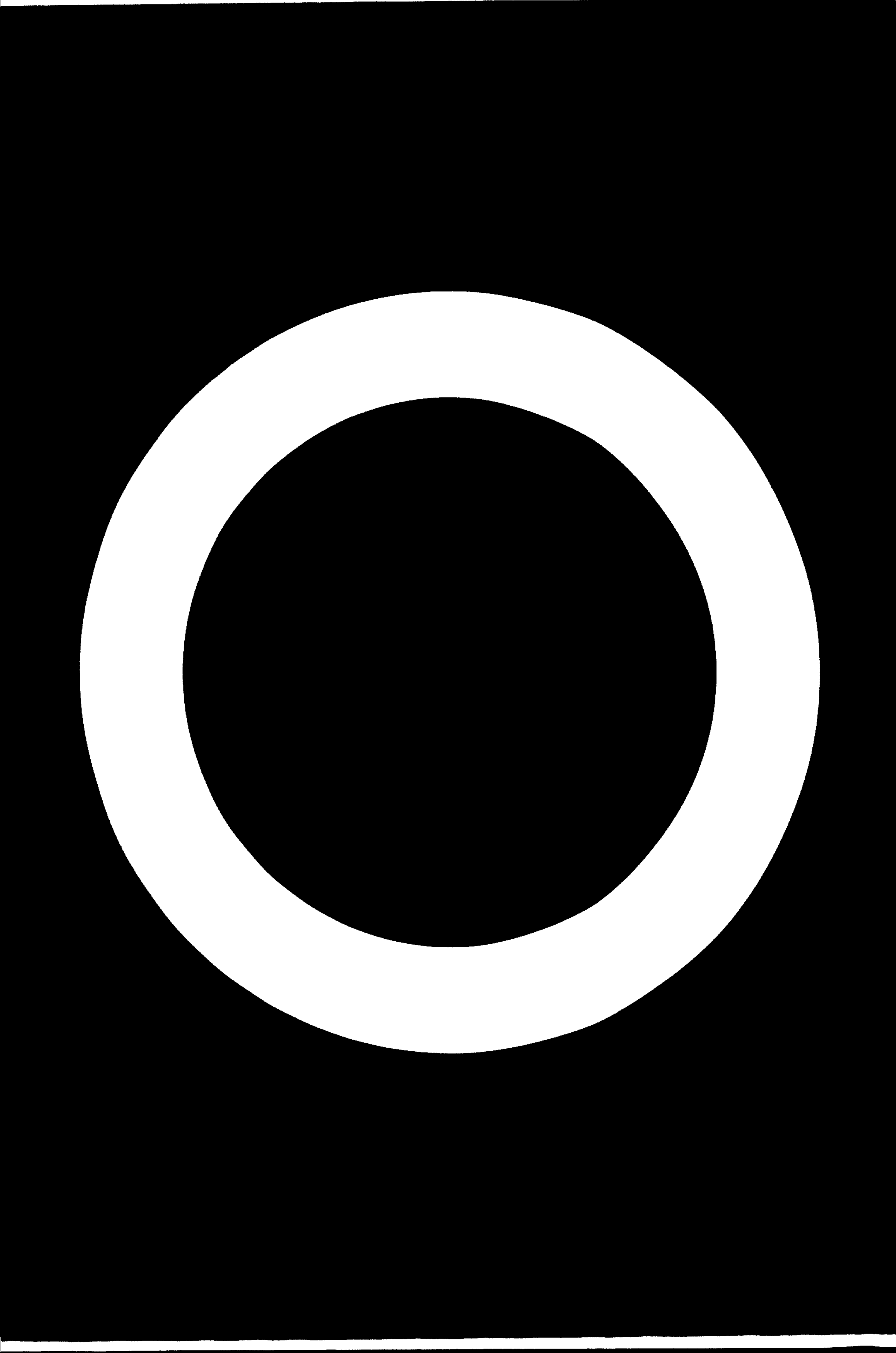
(4) Production Management

Comparison of SBR and BR shows that SBR generally has more usage than BR. This means that SBR production entails very complicated means of production management. In this sense, BR production should be easier as compared to SBR.

11-4 Conclusion

In consideration of the above market studies and the factors stated in "11-3 Other Considerations", we have selected BR as synthetic rubber to be produced in Kuwait and have decided on BR plant capacity of 25,000 tons/year.

In consideration of the total prospective demand for BR produced in Kuwait and the start up operation at 70% and the operation at 100% in three years, the start up date have been set at 1981.



III Technical Study

III-1 Plant Location

(1) Plant Site

Shuaiba Industrial Area was proposed by the Shuaiba Area Authority as a prospective site for the butadiene rubber industry. The site was selected in 1964 for the setting up of an ideal industrial complex utilising the national resources in Kuwait. It is situated 50 km to the south of Kuwait City and faces the Arabian Gulf.

In the area, a petroleum refining plant, fertilizer plants, etc., have already been located and in operation.

(2) Land

About 8.4 million sq.m of the Area have been developed and further approximately 6 million sq.m are reserved for future extension. The land area is sufficient for the BR plant and it will be available at an annual rental fee of 75KD per 1,000 sq.m.

(3) Availability of Utility

According to the Shuaiba Area Authority's rule in providing services and utilities to the industries in this Area, electric power, water and fuel gas are supplied directly or indirectly by the Authority.

According to the Shuaiba Area Authority, sufficient quantities of the abovementioned utilities would be supplied to the [illegible] plant at the border of the site.

Current supplying status is as follows:

a) Electric power

At present, electric power is served by the following two power stations in the area.

Shuaiba North Power & Water Production Station
Total Capacity: [illegible]

Shuaiba South Power & Water Production Station
Total Capacity: [illegible]

In 197[illegible], electric power consumption by existing industries in this Area was [illegible]. A new power plant with a capacity of [illegible] is being constructed at Doha and it will be connected to the existing electrical loop.

Electric power will be supplied at a price of 1 Fill per [illegible].

b) Water

a. Cooling water

At present, about 2,000 million cu.m per year of sea water is taken in by a pumping station and distributed to the existing users at a price of 1.99 fills per cu.m. Also, construction of an additional sea water pumping station is being considered at the northern part of the Area.

b. Distilled water (for process water and source of boiler feed water)

At present, distilled water is served at a price of 0.25 Fills per gallon by the Power & Water Production Stations mentioned in (3) a) above and their total production capacity is 44 million gallons per day.

c) Fuel Gas (Natural Gas)

At present, about 80,000 million cu.ft. per year of natural gas is supplied at a price of 0.49 Fills per cu.m.

After completion of a new LPG plant the price will be changed. It is suggested by the Authority that the price will be 20 Fills per thousand standard cu.ft. (as 1,000 BTU gas), for reference.

(4) Harbor Facilities

The existing harbor at the Shuaiba Industrial Area (Port of Shuaiba) consists of the Shuaiba Commercial Harbor, the Barge Harbor and the Oil Pier.

The Commercial Harbor is utilized for the importation of materials and equipment required for the industries in the Area, as well as for the exportation of products of the fertilizers and sulfur industries. The Oil Pier is utilized to handle oil products and liquid ammonia for export.

The existing port facilities of the Commercial Harbor are as follows:

Five berths with depths varying between 23 and 37 ft. (for 25,000-30,000DWT), having a total hadling capacity of about 1 million tons per year.
Five cranes with capacities of 5 tons and 3 tons are provided on the main mole.

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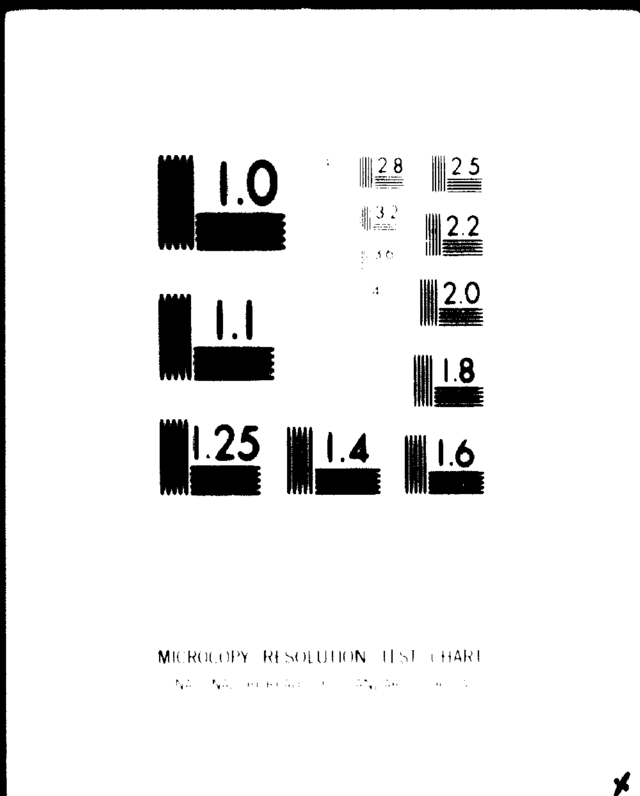

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The Shuaiba Area Authority has a new harbor expansion plan with a depth for 65,000DWT cargo and cranes with capacity of 10 and 20 tons at the northern part of the existing port.

Harbor capacity will be sufficient for exporting the BR.

(5) **Raw Material Supply**

According to the Ministry of Oil, sufficient quantities of butane will be readily supplied from the existing or the new LPG plant by pipeline.

The price will be current F.O.B. price for export, which is presently estimated to be 120 US dollers per ton.

(6) **Labor Force**

Though recruitment of skilled and unskilled labor from Kuwaiti nationals seems not easy due to its limited population, past experience shows that a number of huge construction projects have been carried out in Kuwait hiring immigrant labor forces from neighbouring and Asian countries. Therefore, no major problem is foreseen as to the availability of labor force.

III-2 Production Scheme

Production scheme for 25,000 tons per year of BR based on butane is illustrated in Fig. III-1.

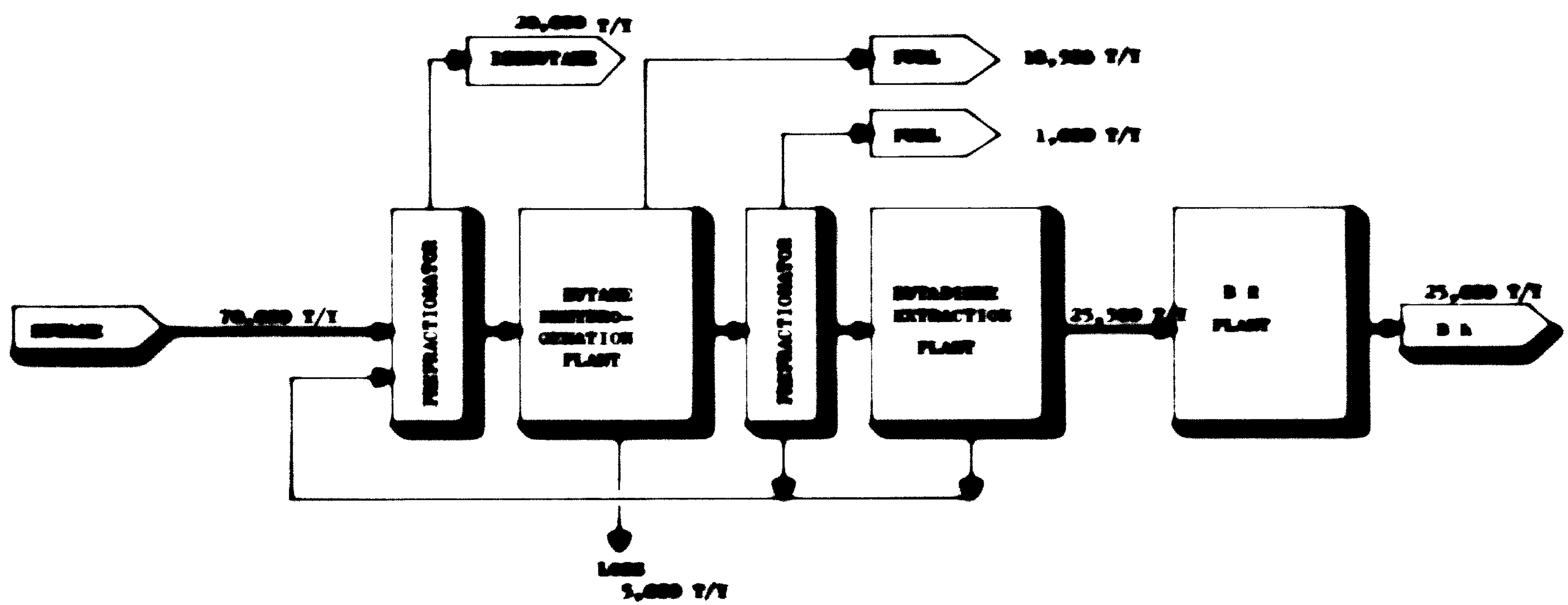
The scheme consists of a butadiene production section and a BR production section.

Butane fraction from the LPG plant is charged to a feed prefractionator and purified to over 98 percent of normal butane which is a required purity for the feedstock for the butane dehydrogenation plant. Isobutane removed from the feed prefractionator will be sold as LPG or sent back to the LPG plant.

In the butane dehydrogenation plant, normal butane is converted to butenes and butadiene. The butadiene rich stream is processed by the extraction feed prefractionator to enrich the butadiene content, and is sent to the butadiene extraction plant.

In the butadiene extraction plant, butadiene is recovered with a purity of over 99 per cent as the feedstock for the BR production section.

The streams removed from the extraction feed prefractionator and butadiene extraction plant consisting of butane and butenes are recycled to the dehydrogenation plant to yield more butadiene. Finally, butadiene is polymerised to the product in the SBR production section.


20,000 T/Y
10,500 T/Y
1,000 T/Y
70,000 T/Y
PREFRACTIONATOR
BUTANE
GENATION
PLANT
PLANT
25,500 T/Y
D R
PLANT
25,000 T/Y
LOSS
5,000 T/Y

III-3 Production Technology

(1) Butadiene Production

a) Butane Dehydrogenation

Licensor	Licensing availability in this stage
o Air Products and Chemicals (USA) (Houdry)	Available
o Phillips Petroleum (USA)	Available

Houdry Single-Stage process (Catadiene process) and Phillips Two-Stage process are currently available for production of butadiene from normal butane.

In the Houdry Catadiene process, which utilizes catalyst consisting of activated alumina impregnated with chromic oxide, n-butane is dehydrogenated to butadiene in a single-stage reactor by the following reaction at an elevated temperature (593-676°C):

$$C_4H_{10} \xrightarrow{-H_2} C_4H_8 \xrightarrow{-H_2} C_4H_6$$

Because of the thermodynamic limitations, the conversion per pass to butadiene from normal butane is not complete and unconverted reactants are separated in the following butadiene extraction plant and recycled to the reactor.

In the Phillips' Two Stage Process, normal butane is dehydrogenated over chromia-alumina catalyst in the first stage. Produced butenes are separated from butane by extractive distillation. Unconverted butane is recycled to the first stage of reactor. Butenes and small quantities of butadiene are dehydrogenated in the second stage of the Phillips process named O-X-D process (Oxidative dehydrogenation process).

The Phillips O-X-D process itself seems attractive in the case where butenes are available as the feedstock. However in Kuwait, as normal butane is the feedstock, Houdry's Catadiene Process is recommended because it is more simple and inexpensive in investment and operating cost than the two-stage process.

b) <u>Butadiene Extration</u>

Licensor	Licensing availability in this stage
o Nippon Zeon (Japan)	Available
o Badische Anilin und Soda-Fabrik (BASF) (F.R.Germany)	Not confirmed
o Shell Chemical (USA)	Not confirmed
o Phillips Petroleum(USA)	Available
o Union Carbide (UCC) (USA)	Not confirmed

Extractive distillation method is the most common and recommendable technology to obtain butadiene from dehydrogenated mixture.

The characteristics of each process lie in the solvent and its usage.

Essentially, butadiene is selectively solved in a solvent and then separated from the solvent by stripping.

Table III-1 shows typical properties of solvent used in each of the process.

Table III-1 Typical Properties of Solvent

Licensor	Nippon Zeon	BASF	Shell	Phillips
Solvent	Dimethyl Formamide (DMF)	N-methyl Pyrrolidone (NMP)	Acetonitrile (ACN)	Furfural
Molecular Weight	73.09	99.13	41.05	96.08
Boiling Point	153 - 155	204 - 209	80 - 82	162
Sp. Gr. (20°C)	0.944(25°C)	1.030	0.788(15°C)	1.164
Solubility				
n-Butane (wt%)	39	30	26	16
1.3 Butadiene (ML/ML at 20°C)	82	77	63.4	-
Selectivity (B coeff. 40°C)	1.60	1.66	1.47	1.59

The recommendable processes are the Nippon Zeon's (GPB Process) and BASF's by their higher selectivity of the solvent, which enables an effective separation with smaller solvent flow rate and higher quality of product.

While the BASF process employs NMP (N-methyl pyrrolidone) as a selective solvent with a 5-20 vol. percent of water, the GPB Process adopts DMF (Dimethyl Formamide) without water. One of the important considerations is how to solve the problem of plugging caused by polymerized butadiene in the process. In the GPB process, polymerization inhibitor which is easily available as a common chemical is added in the solvent. In BASF's process, the water is added in the solvent to reduce the operating temperature since the polymerization reactions tend to occur at a higher temperature.

However, the solubility of butenes-butadiene hydrocarbons is tremendously reduced by the presence of water.

Another important problem is to prevent a formation of popcorn polymer of butadiene caused by the presence of oxygen. As water contains trace of dissolved air (oxygen), the processes using the solvent with water had been developed special technologies such as complete purging of oxygen from water or addition of some chemicals as inhibitor.

(2) BR Production

Typical Licensor	Licensing availability in this stage
o Japan Synthetic Rubber(Japan)*	Available
o Phillips Petroleum(USA)*	Available

o Firestone Synthetic * Rubber & Latex (USA)	No
o B. F. Goodrich Chemical * (USA)	Available
o Polysar (Canada)	Available
o Goodyear Tire & Rubber (USA)	Available (Negotiable with Licensee)
o Nippon Zeon (Japan)	Will be available
o Chemische Werke Hüls(F.R.Germ.)	Available

The licensors marked with an asterisk, can license both patent on catalyst and process know-how, while the other three licensors have their processes available for licensing, but their patent situation has not yet been confirmed. For BR production, solution polymerization processes are the most common technology and they are characterized by the type of catalyst as shown in Table III-2.

Table III-2 Type of Catalyst and Polymer Configuration

Type of Catalyst	Original Licensor	Polymer configuration(%)		
		Cis 1,4-	Trans 1,4-	1,2-
Nickel-based	Japan Synthetic Rubber	97	1 - 2	1 - 2
Cobalt-based	Goodrich Gulf	96-98	1 - 2	1 - 2
Tithanium-based	Phillips Petroleum	94	2	4
Lithium	Firestone	40	51	9

Most BR made by the processes listed in Table III-8 have a high and medium cis-1,4 content which exhibits advantageous characteristics. The Firestone catalyst gives approximately equal cis-and trans 1,4 content but a narrow range of molecular weight distribution is expected.

All processes consist of the following steps commonly.

1. Chemicals and catalyst preparation
2. Butadiene monomer and solvent purification
3. Polymerization with refrigeration system
4. Solvent and unreacted butadiene recovery
5. Polymer drying and finishing

For each step, a number of important know-how and techniques for design and operation have been developed. For example:

- Type and preparation method of catalyst
- Solvent selection
- Heat removal system
- Polymer, solvent and unreacted butadiene separation
- Systematic handling of viscid and solid materials

III-4 Production Facilities

(1) Butadiene Production

a) Butane Dehydrogenation Plant

(Houdry Catadiene Process)

Fig. III-2 shows a simplified flow scheme including feed prefractionator.

a. Process Description

The n-butane and butenes of a pre-determined purity from the bottom of the feed prefractionator is preheated to the reaction temperature in the heat exchanger and furnace and then charged to one of the reactors. Normally three or more reactors are employed for cyclic operation as follows:

- o Operation (Period 5-10 minutes)
- o Regeneration (Period 5-10 minutes)
- o Purge and Evacuation

Hot hydrocarbon vapors from the reactors are led into the quench tower where the vapors are reduced in temperature by heat exchange with the circulating quench oil stream. Polymerized hydrocarbons formed by side reaction in the reactor effluent are absorbed by the quench oil stream.

Effluent gases from the quench tower are compressed by the compressor and then liquid condensate is separated. This compressor is also used for making the reaction section vacuum.

The vapor is charged to the absorber for rejection of propane and lighters. Absorbent containing butadiene-rich product is charged to the stripper.

The butadiene rich product is stripped from absorbent and charged to the depropanizer where essentially all of the propane lighter components a.e separated from the butadiene rich product. Depropanizer bottoms product is sent to the butadiene extraction section.

In the regeneration period, compressed and heated air is passed through the reactor for heating up the catalyst bed to the initial reaction condition and additionally burning the coke deposited on the catalyst during the preceding reaction period.

b. <u>Major Equipment and Machinery</u>

Columns

Quench tower

Hydrocarbon absorber

Hydrocarbon stripper

Depropanizer

(Prefractionator: not included in the Houdry process)

Reactors

Dehydrogenation reactors

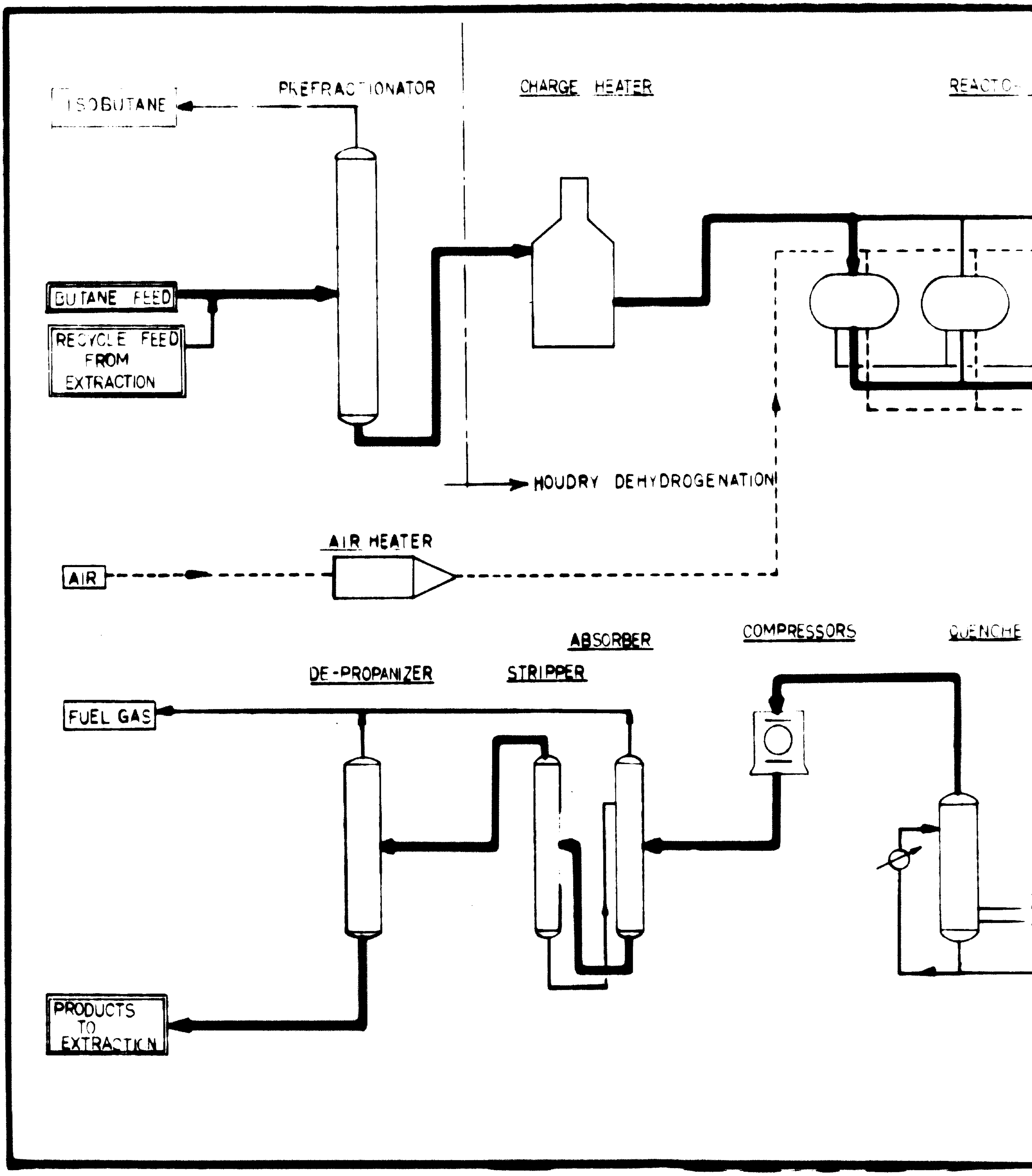
Other Equipment

Air heater

Charge heater

Hydrocarbon compressor

Air compressor


ISOBUTANE
PREFRACTIONATOR
CHARGE HEATER
BUTANE FEED
RECYCLE FEED FROM EXTRACTION
HOUDRY DEHYDROGENATION
AIR HEATER
AIR
ABSORBER
COMPRESSORS
DE-PROPANIZER
STRIPPER
FUEL GAS
PRODUCTS TO EXTRACTION

SECTION 1

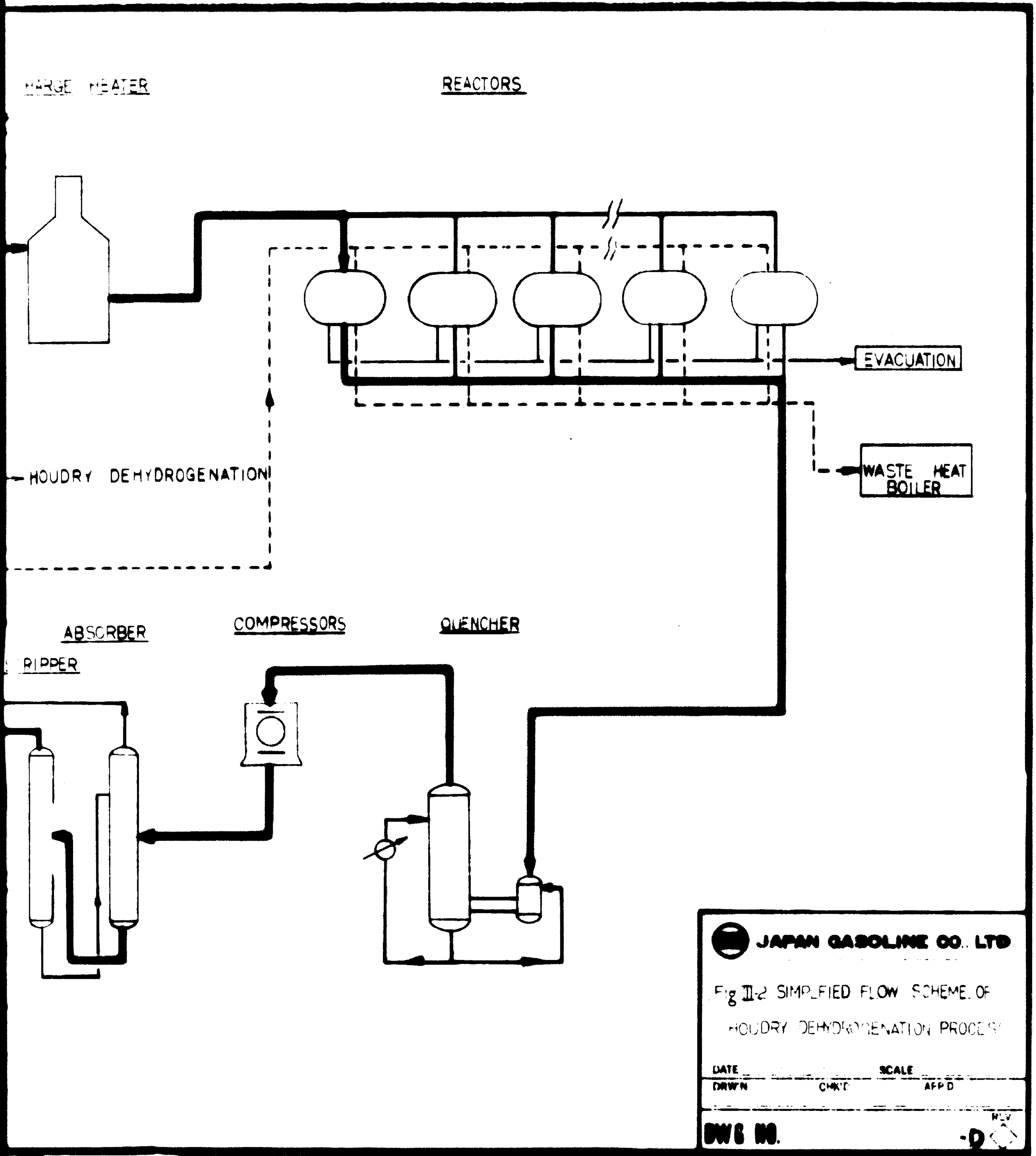


Fig II-2 SIMPLIFIED FLOW SCHEME OF HOUDRY DEHYDROGENATION PROCESS

b) Extraction Feed Prefractionator

a. Process Description

As butadiene content in the product stream from the dehydrogenation plant is low (about 15 per cent), this stream is charged to the prefractionator to enrich the butadiene content and reduce the overall butadiene production cost.

The fractionator consists of two columns.

In the first column, hydrocarbons having higher boiling point than that of butadiene is separated by distillation. Overhead stream containing butadiene is charged to the following extraction plant.

The bottom stream of the column is charged to the second column in which heavier hydrocarbons than butane formed in the dehydrogenation plant is removed.

Butane fraction from the second column is recycled to the dehydrogenation plant.

b. Major Equipment

Columns

Fractionators

Other Equipment

Condensers

Reboilers

c) Butadiene Extraction Plant

(Nippon Zeon Co.'s GPB Process, as a recommendable example)

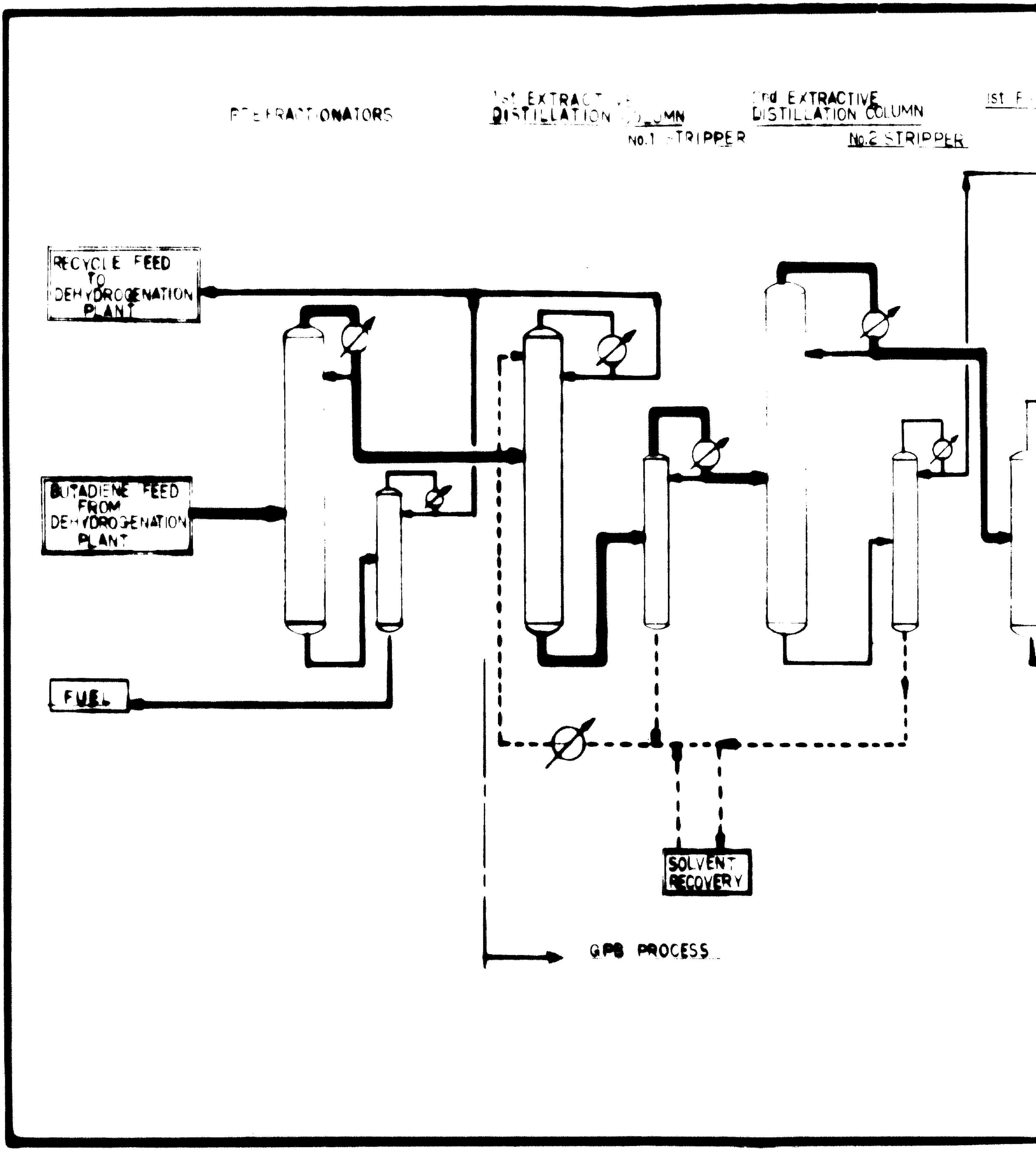
Fig. III-3 shows a simplified flow scheme including feed prefractionators.

a. Process Description

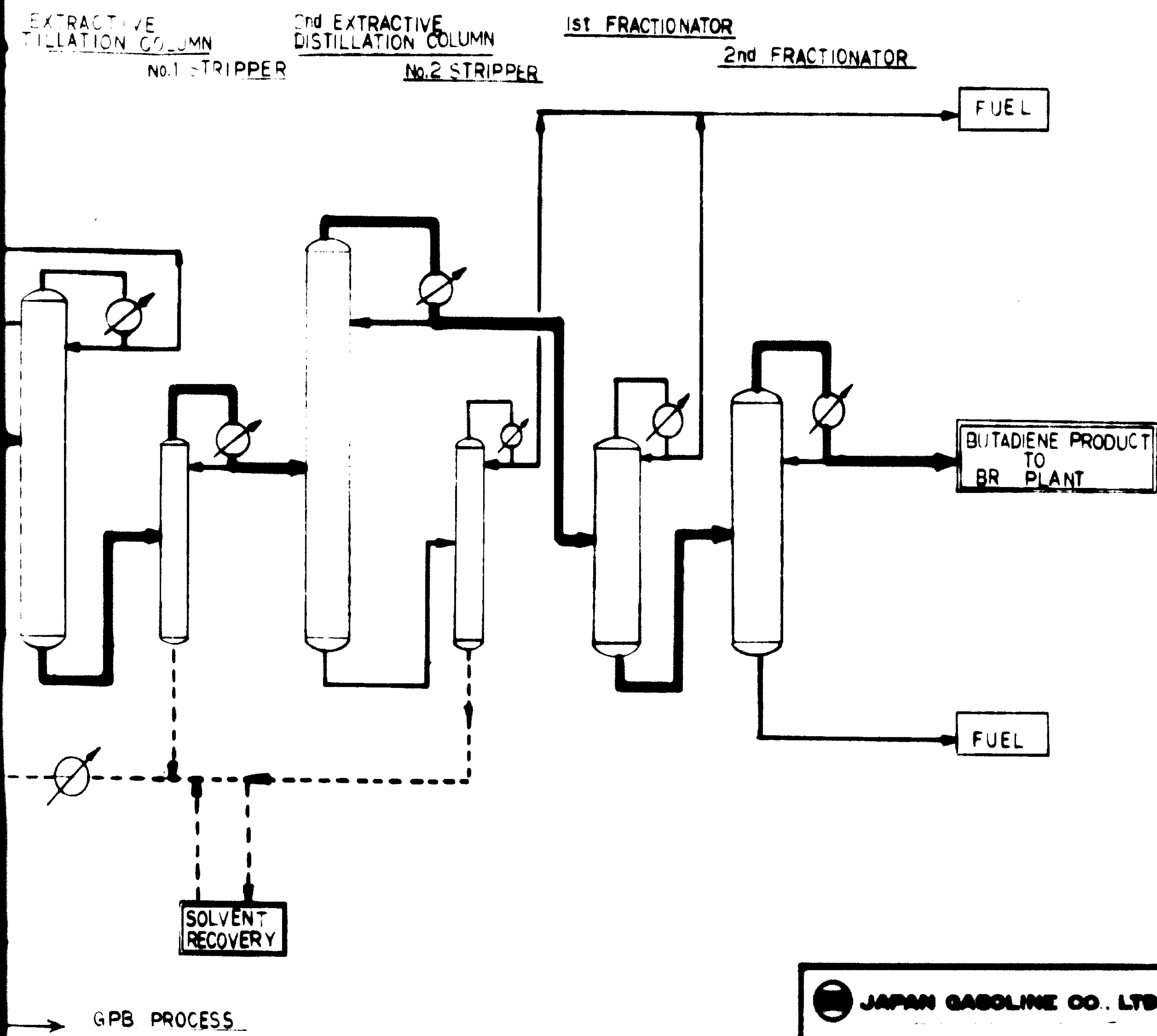
First Extractive Distillation Section

Butadiene-rich stream from the top of the prefractionator is charged to the first extractive distillation column, in which DMF solvent is pumped to the top. In this column, butadiene and a part of butenes are solved in he solvent.

The column overhead stream, consisting mainly


PREFRACTIONATORS
1st EXTRACTIVE DISTILLATION COLUMN
No.1 STRIPPER
2nd EXTRACTIVE DISTILLATION COLUMN
No.2 STRIPPER
RECYCLE FEED TO DEHYDROGENATION PLANT
BUTADIENE FEED FROM DEHYDROGENATION PLANT
FUEL
SOLVENT RECOVERY
GPB PROCESS

SECTION 1



JAPAN GASOLINE CO., LTD.

Fig II-3 SIMPLIFIED FLOW SCHEME OF GPB PROCESS

DATE SCALE
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of butane and butenes, is recycled to the dehydrogenation process. The solvent stream from the bottom of the first extractive distillation column containing mainly butadiene is charged to the first stripper, where the hydrocarbons containing butadiene are stripped from the solvent which is then cooled and pumped back to the first extractive distillation column. The stripped hydrocarbons are charged to the second extractive distillation column.

Second Extractive Distillation Section

The DMF solvent is pumped to the top of the second column to dissolve components more soluble in DMF than butadiene. The column overhead vapour, which is butadiene containing trace impurities, is condensed, and net overhead is charged to the straight distillation columns for final purification.

The solvent stream from the bottom of the second extractive distillation column is pumped to the second stripper, where the remaining hydrocarbons are stripped form the solvent, which is then cooled and pumped back to the first and second extractive distillation columns.

Straight Distillation Section

Small amounts of impurities still present in the butadiene fraction after the two stages of extractive distillation are subsequently removed in the straight distillation section.

The first fractionator removes impurities of boiling point lower than that of 1, 3-butadiene, and the second fractionator removes impurities of boiling point higher than that of 1, 3-butadiene.

Solvent Recovery Section

The process solvent includes very small amounts of water from raw C_4 feed and polymers formed in the system. The drainage from the separator and small side-stream of the circulating solvent are sent to the solvent recovery section, which consists of a low-boils removal column and high-boils removal units, to eliminate the above contaminants. The recovered solvent is then recycled to the main process.

b. **Major Equipment and Machinery**

Columns

- First extractive distillation column
- Second extractive distillation column
- Strippers
- Fractionators

Other Equipment

- Condensers
- Reboilers

(2) **BR Production Facilities**

(Japan Synthetic Rubber Co.'s JSR BR Process, as a recommendable example)

Fig. III-4 shows a simplified flow scheme.

a) **Process Description**

Solvent and Butadiene Purification Section

Recovered and recycled solvent from solvent stripping section is purified by distillation in a series of columns. Butadiene, water and non-volatile material contaminating the solvent are removed.

Butadiene, both fresh and recovered from butadiene stripping section, is purified by distillation in a series of columns.

Water and contaminating impurities such as by-produced dimers are rejected.

Catalyst and Chemical Preparation Section

Catalyst solutions and chemical solutions such as shortstopper, antioxidant and inhibitor etc. are prepared separately beforehand to be charged into the polymerization section.

Continuous Polymerization Section

Purified butadiene and solvent are pumped separately at prescribed flow rates, precooled through respective precoolers, and both streams converge into single stream entering the first reactor in the chain. Catalyst streams are also mixed in this stream to initiate reactions, and while passing through the reactor chain exothermic polymerization of butadiene takes place, giving polymer cement of a high viscosity. The removal of reaction heat at this stage is quite an important problem, and from such view, reactors, agitators, as well as cooling system utilizing a refrigerant are specially designed to ensure steady and effective polymerization. Shortstopper is added into polymer cement emerging from the last reactor in the chain to terminate polymerization, followed by the addition of antioxidant into the stream to protect products from degradation.

Blending Section

The polymer cement is led into one of blend tanks which serve as both intermediate and buffer tanks, where it is homogenized by mixing as a lot of product, then subjected to process control test to assure the final products meeting specification limits, then pumped to the succeeding monomer and solvent stripping section.

Solvent and Unreacted Monomer Stripping Section

The solvents and unreacted butadiene are removed by the addition of steam. The polymer cement from the blend tanks enters the first stripper in the chain.

When oil extended types of rubber are being produced, the oil is continuously metered into the stream of polymer cement, homogenized through the line blender and fed to the first stripper. In the first stripper the polymer cement is coagulated and coverted into a slurry by the addition of recycle water and by vigorous agitation, then flows into the second and third strippers under similar conditions and pumped into the crumb slurry tank.

Vapors of solvent and unreacted butadiene removed by steam stripping from polymer are condensed and separated from water by decantation, then recycled to the respective purification sections.

Finishing Section

From the crumb slurry tanks, which are provided as a buffer, crumb slurry is pumped to the shaker screen where water is removed from crumb slurry and partly recycled to the stripping section.

The separated crumb is then fed to the drier for further dewatering, subsequently dried through the expander to a moisture content below specification limit. The dried rubber crumb is fed through conveyors and weigh scale to the baling press, through which compressed into a bale.

The bales are carried by conveyors, visually inspected, scanned for metals, then wrapped and packed for shipment.

b) Major Equipment and Machinery

Column

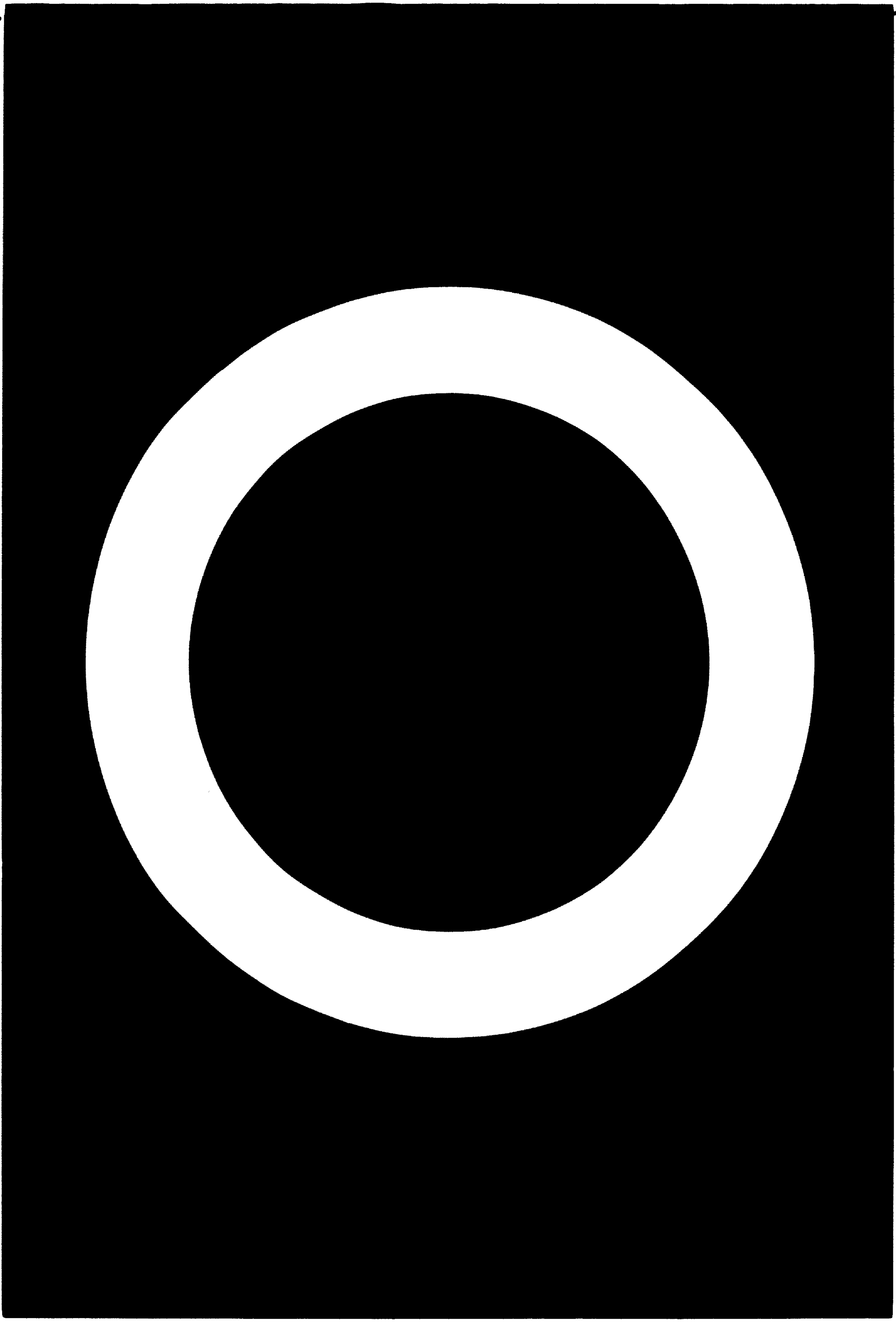
- Butadiene purification columns
- Solvent purification columns
- Stripping columns

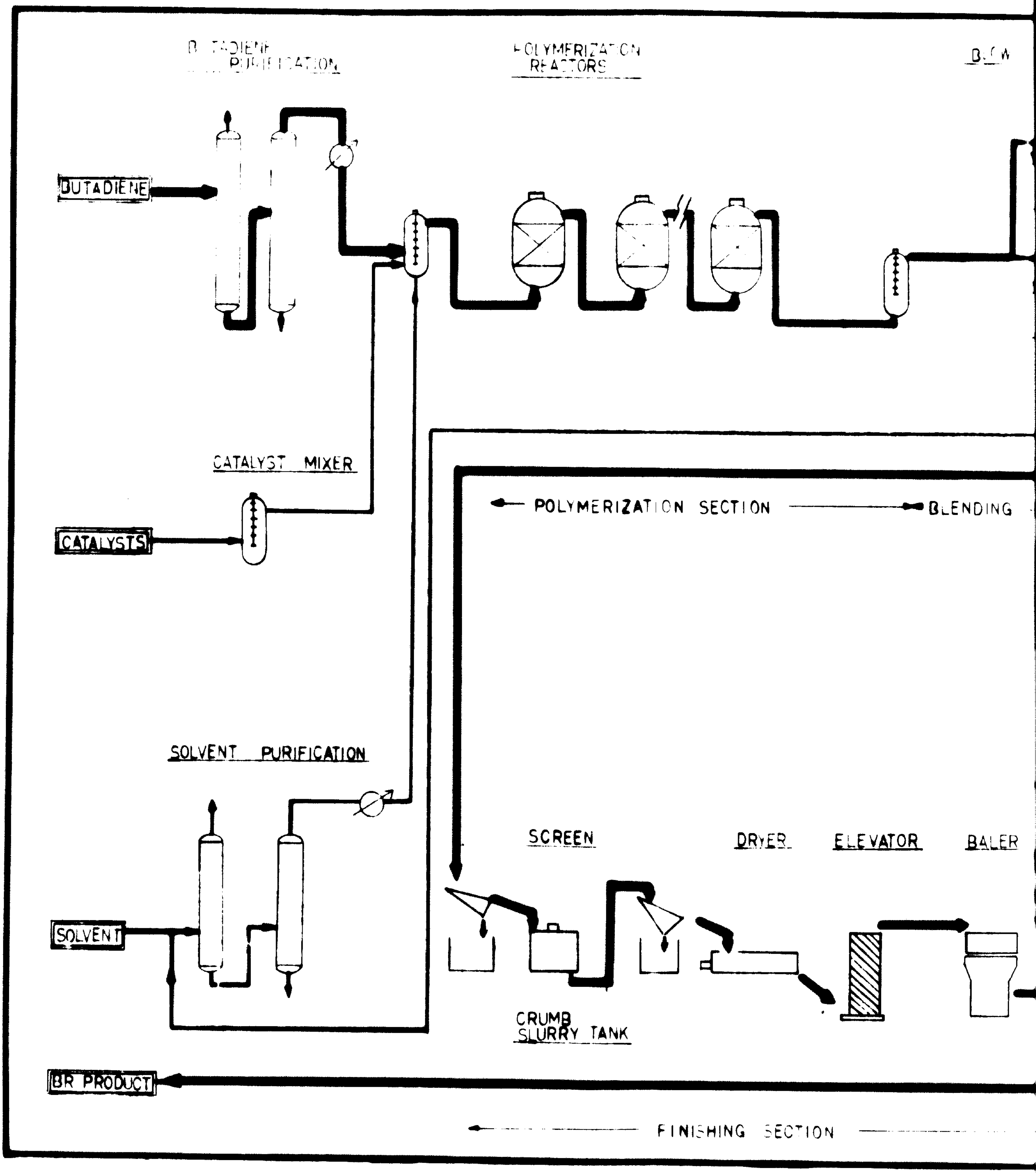
Reactor

- Reactors with agitator and refrigeration system

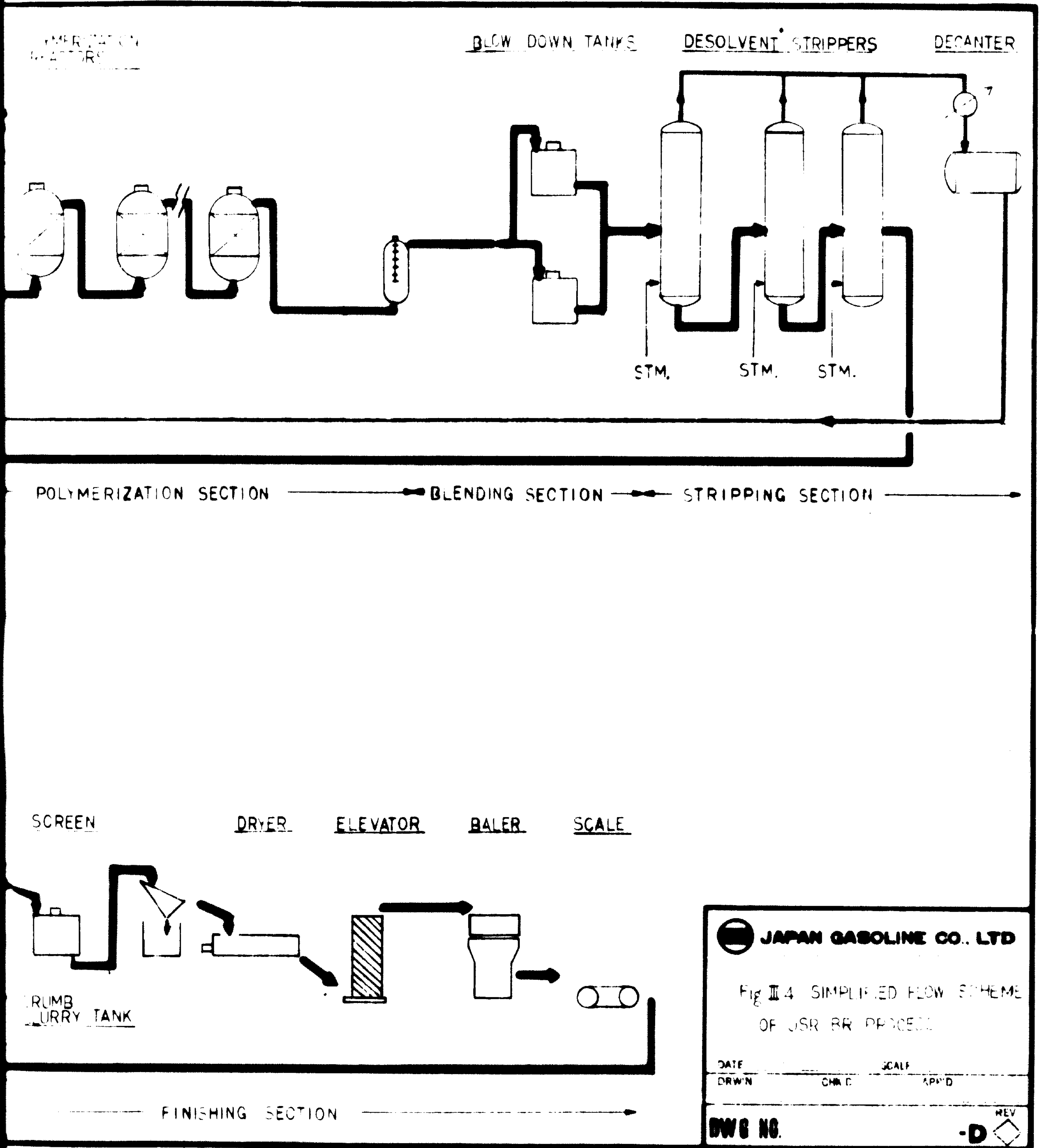
Other Equipment & Machinery

- Finishing System
  - Shaker screen
  - Dryer
  - Elevator
  - Baler
- Blow down tanks
- Crumb slurry tanks




BUTADIENE
CATALYST MIXER
CATALYSTS
SOLVENT PURIFICATION
SOLVENT
BR PRODUCT
POLYMERIZATION SECTION
BLENDING
SCREEN
DRYER
ELEVATOR
BALER
CRUMB SLURRY TANK
FINISHING SECTION

SECTION 1



JAPAN GASOLINE CO., LTD

Fig III 4 SIMPLIFIED FLOW SCHEME OF JSR BR PROCESS

(3) Offsite Facilities

a) Utility Facilities

Utility requirements for production of 25,000 tons per year of BR based on butane feedstock are shown in Table III-3.

Table III-3 Estimated Utility Requirements

		Butadiene Production	BR Production	Offsite	Total
Electricity	KWH/H	860	1,800	350	3,010
Steam	T/H	48	27	75 (Produced)	-
Process water	M^3/H	37 (Condensate recovered)	24	75	62
Cooling water	M^3/H	3,700	1,000	100	4,800
Fuel	MM kcal/H	6 (Produced)	-	69	63
Nitrogen	NM^3/H	80	40	-	120
Instrument Air	NM^3/H	400	200	30	630

Since most of the above utility requirements are fulfilled by the Shuaiba Area Authority, the necessary utility facilities for the BR production plant to be built in the Area are as follows:

. Electric substation

. Steam boilers

b) <u>Tank and Warehouse</u>

a. The following tanks are provided for storage of raw material and intermediate products. All of the tanks are of the spherical type. Capacities of the tanks are determined to store two or seven days' each of material depending on the nature of the substance stored.

o	Raw material	two units
o	Isobutane	two "
o	Butadiene rich intermediate	two "
o	Butadiene	two " (with cooling equipment)
o	Raffinate	two "
o	Off spec. butadiene	one "

b. Warehouse to store 45 - 50 days' product is provided. Around 3,800 sq.m. of area of the warehouse is required.

c) <u>Waste Disposal</u>

a. <u>Waste Water</u>

Approximately 1,900 tons per day of effluent water contaminated with small amount of hydrocarbons and rubber particles come out of the plants. The waste water is disposed of by a settler and then activated sludge treatment. The kind of facility will be selected after butadiene and BR processes have been determined.

b. Waste Polymer

Waste polymers such as scraps collected in plant cleaning are burnt in an incinerator.

c. Waste Gas

Outlets of all pressure safety valves are connected to the relief header system and burnt at the central flare stack.

d) Other Facilities

Other facilities to be considered are listed below:

Administration building and equipment
Laboratory building and equipment
Maintenance shop and equipment
Material warehouse
Firefighting facility

Fence

Roads

Parking yard

III-5 Plant Layout

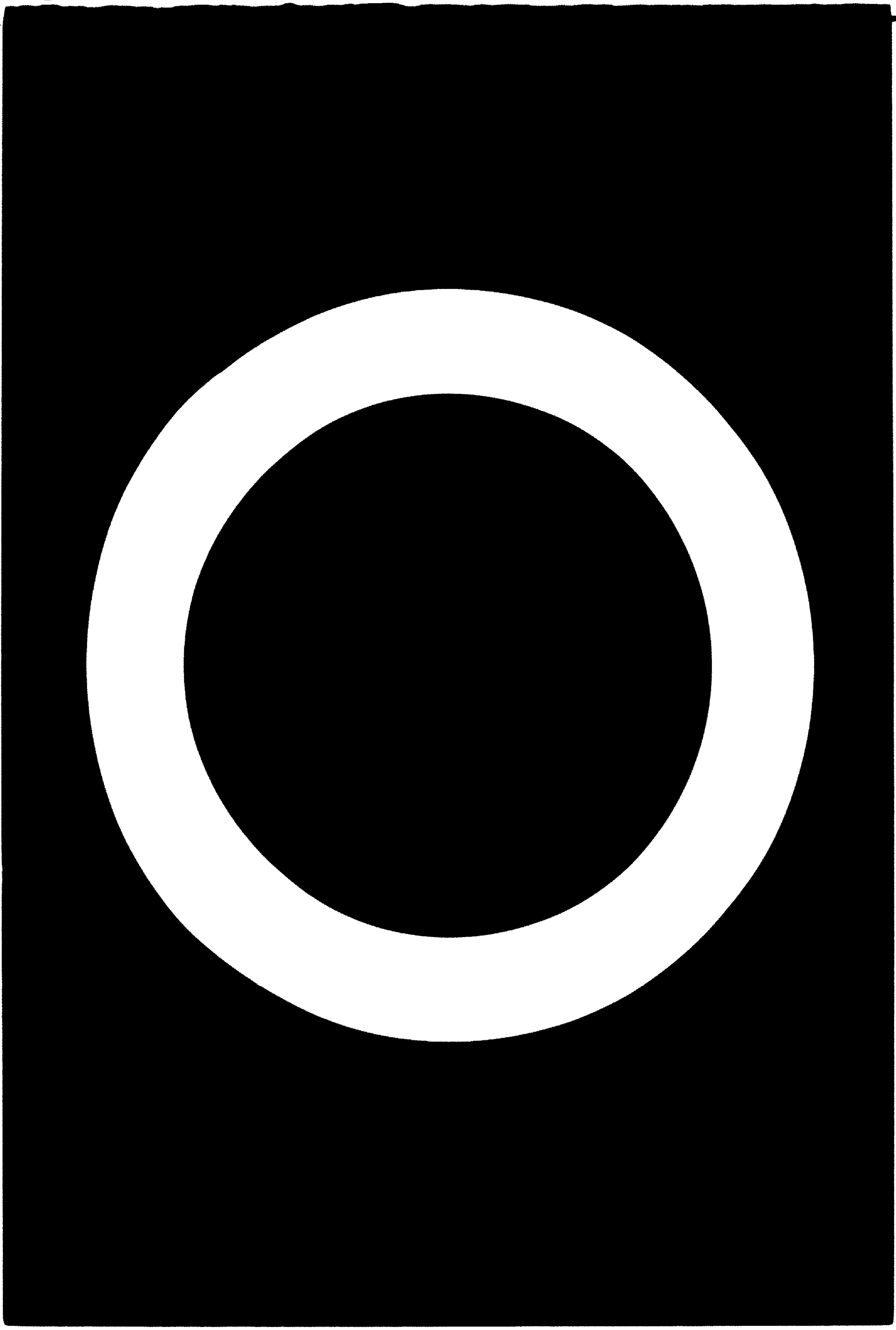
The most recommendable site for the BR plant in the Shuaiba Industrial Area is tentatively selected as shown in Fig. III-5 while the final selection should be made by the Authority.

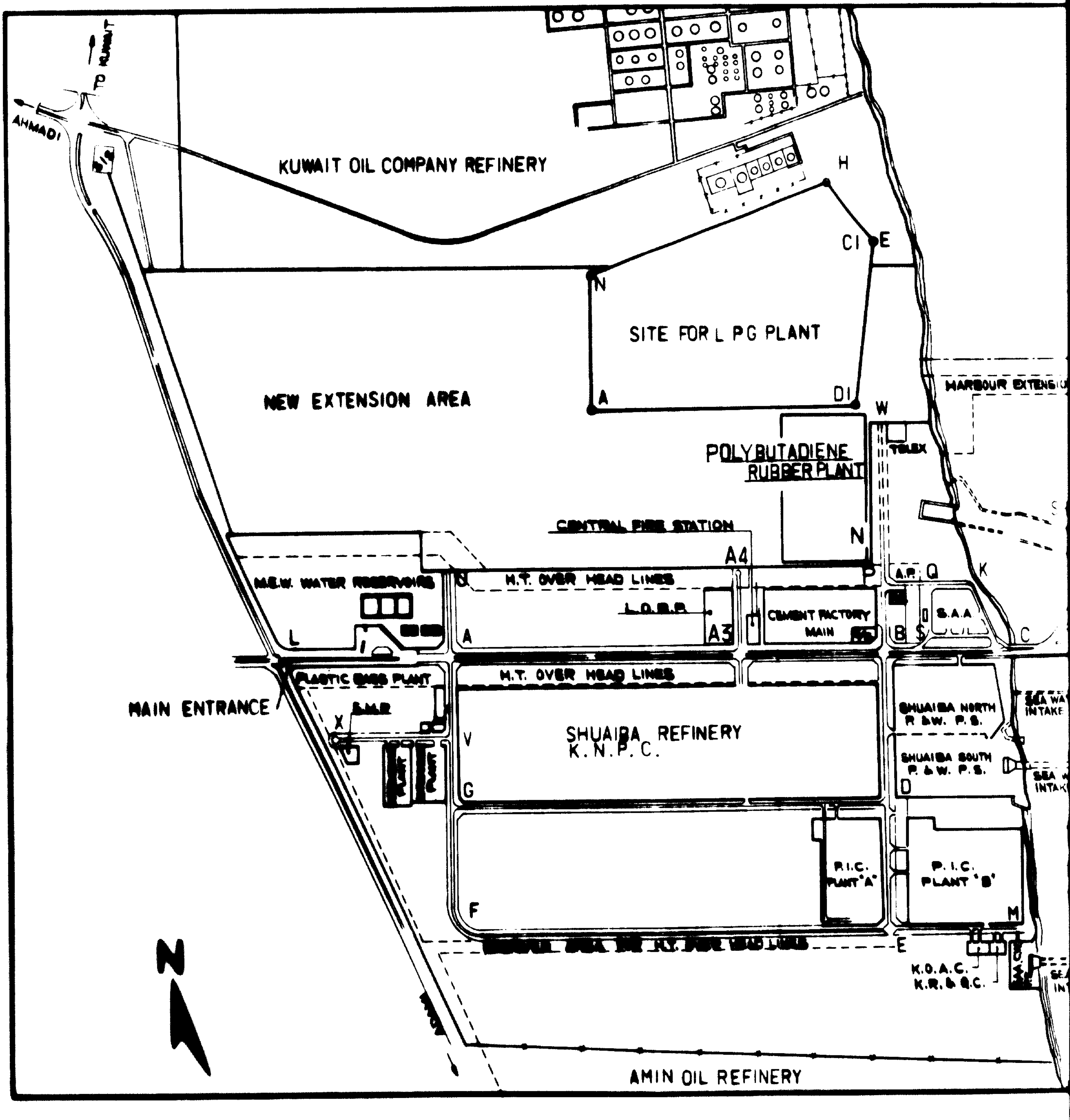
The site faces the coastline and is adjacent to the new LPG plant which will supply raw material to the BR plant.

The required area is 375,000 sq.m. (750m x 500m) including the space for future expansion.

Overall layout as shown in Fig. III-6 is proposed taking the following items into account.

- Easy access from the existing road
- Effective material handling
- Consistency with activity relationship diagram
- Future expansion to double the presently proposed production capacity
- Other factors such as safety, environmental protection, etc.





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KUWAIT OIL COMPANY REFINERY
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SITE FOR L PG PLANT
NEW EXTENSION AREA
A
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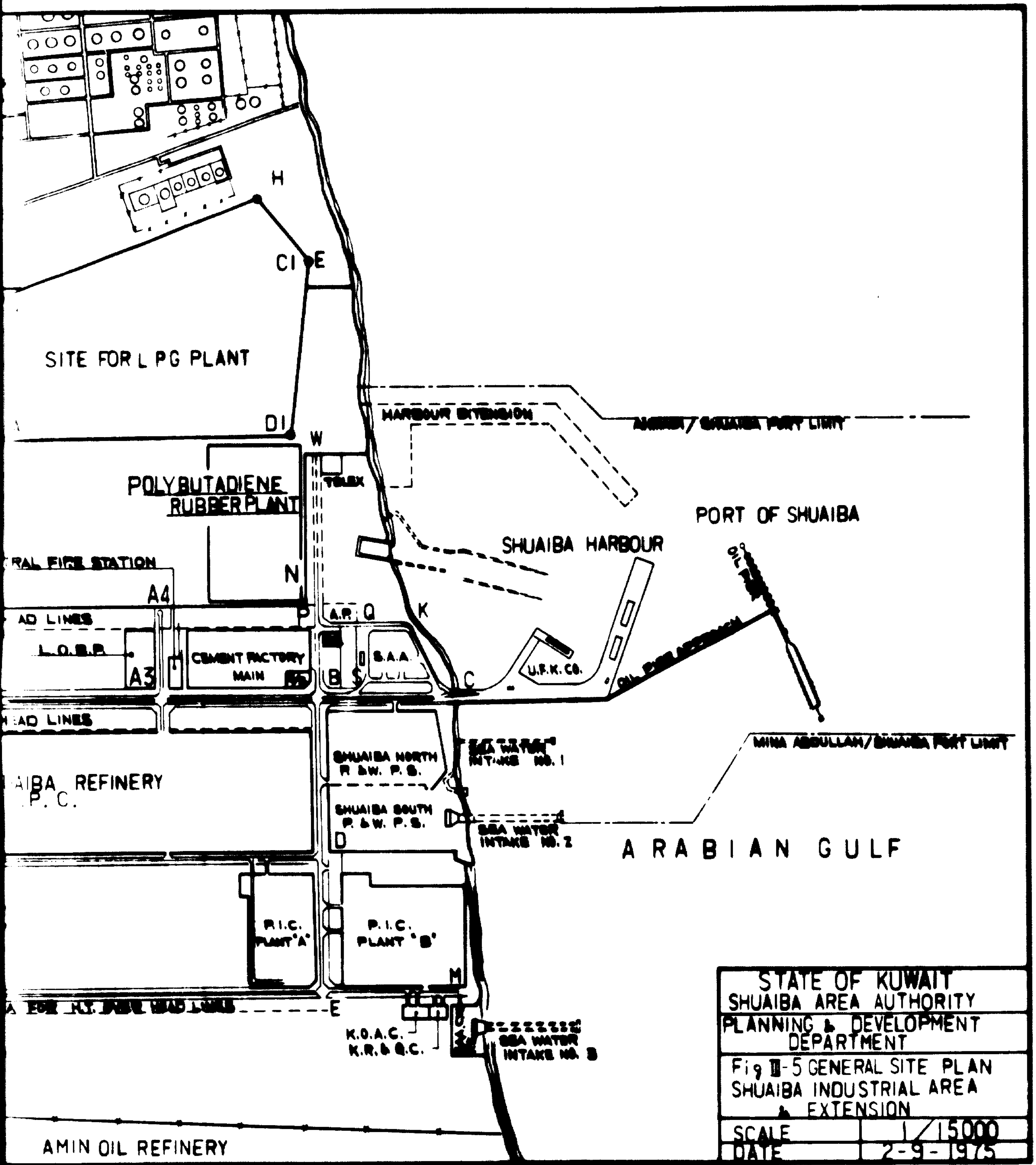
HARBOUR EXTENSI
POLYBUTADIENE
RUBBER PLANT
TELEX
CENTRAL FIRE STATION
N
A4
H.T. OVER HEAD LINES
M.E.W. WATER RESERVOIRS
A.P.
Q
K
L.O.B.P.
CEMENT FACTORY
MAIN
S.A.A.
A3
L
A
B
S
C
PLASTIC BAGS PLANT
H.T. OVER HEAD LINES
MAIN ENTRANCE
X
V
SHUAIBA REFINERY
K.N.P.C.
SHUAIBA NORTH
P. & W. P. S.
SEA WA
INTAKE
SHUAIBA SOUTH
P. & W. P. S.
SEA W
INTAK
G
D
P.I.C.
PLANT "A"
P. I. C.
PLANT "B"
F
M
E
K.O.A.C.
K.R. & Q.C.
N
AMIN OIL REFINERY

SECTION 1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TELEX
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RUBBER PLANT
PORT OF SHUAIBA
SHUAIBA HARBOUR
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A4
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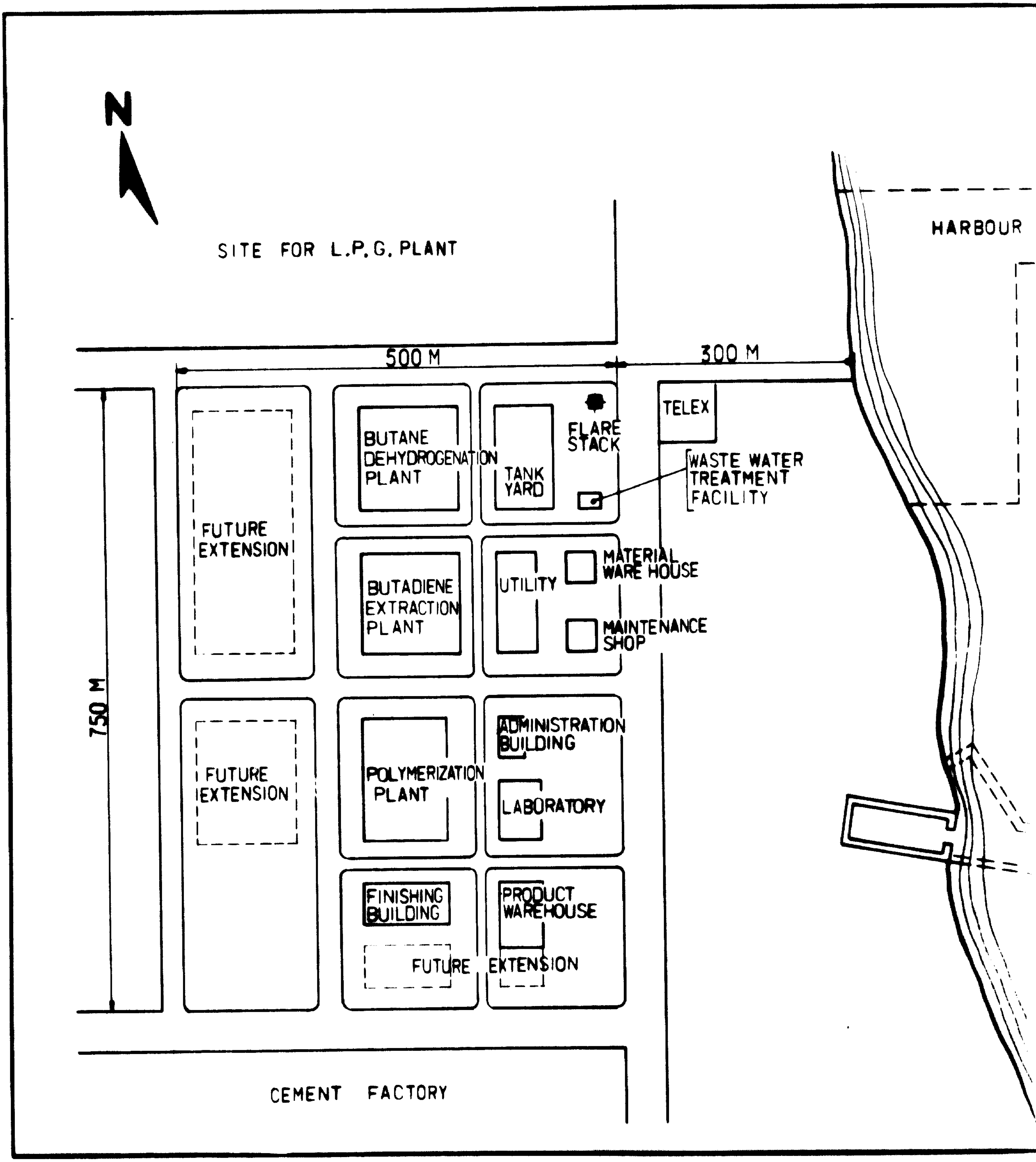
Q
K
L.O.B.P.
CEMENT FACTORY
MAIN
A3
B
S
S.A.A.
C
U.F.K. CO.
SHUAIBA NORTH
P. & W. P. S.
SEA WATER
INTAKE NO. 1
MINA ABDULLAH/SHUAIBA PORT LIMIT
REFINERY
SHUAIBA SOUTH
P. & W. P. S.
SEA WATER
INTAKE NO. 2
D
ARABIAN GULF
P.I.C.
PLANT 'A'
P.I.C.
PLANT 'B'
M
E
K.O.A.C.
K.R. & Q.C.
SEA WATER
INTAKE NO. 3
AMIN OIL REFINERY
STATE OF KUWAIT
SHUAIBA AREA AUTHORITY
PLANNING & DEVELOPMENT
DEPARTMENT
Fig II-5 GENERAL SITE PLAN
SHUAIBA INDUSTRIAL AREA
& EXTENSION
SCALE 1/15000
DATE 2-9-1975


N
SITE FOR L.P.G. PLANT
HARBOUR
500 M
300 M
750 M
TELEX
FLARE STACK
WASTE WATER TREATMENT FACILITY
BUTANE DEHYDROGENATION PLANT
TANK YARD
FUTURE EXTENSION
BUTADIENE EXTRACTION PLANT
UTILITY
MATERIAL WARE HOUSE
MAINTENANCE SHOP
FUTURE EXTENSION
POLYMERIZATION PLANT
ADMINISTRATION BUILDING
LABORATORY
FINISHING BUILDING
PRODUCT WAREHOUSE
FUTURE EXTENSION
CEMENT FACTORY

SECTION 1

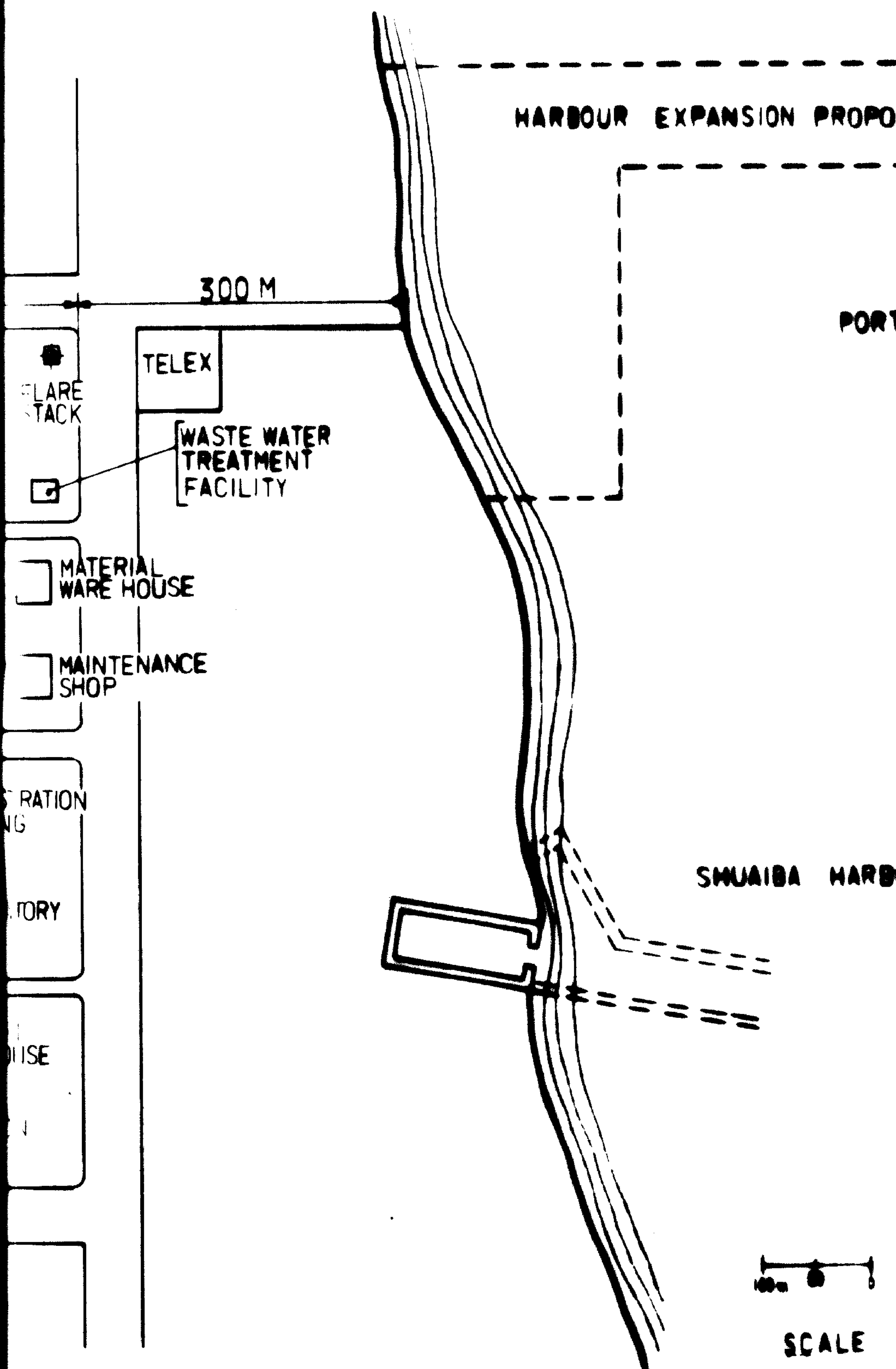


Fig. [illegible]-6 GENERAL LAYOUT OF [illegible] R PLANT (25 000 T/Y)

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SECTION 2

III-6 Construction

The construction schedule by category of work will be as shown in Fig. III-7.
Overall construction period including detailed engineering and test operation is estimated to be thirty-four months.

While local contractors will be invited to bid for civil work in the sixth month from the start of the project, when the basic design data for civil work will be completed by the prime contractor, actual construction work at the site will start from the tenth month.

Required period for the site preparation work will be minimal since the geological conditions are very favorable in the Shuaiba Industrial Area. The first items to be constructed on the site will be field offices, temporary facilities and fabrication shops, and then construction of the foundations will follow.

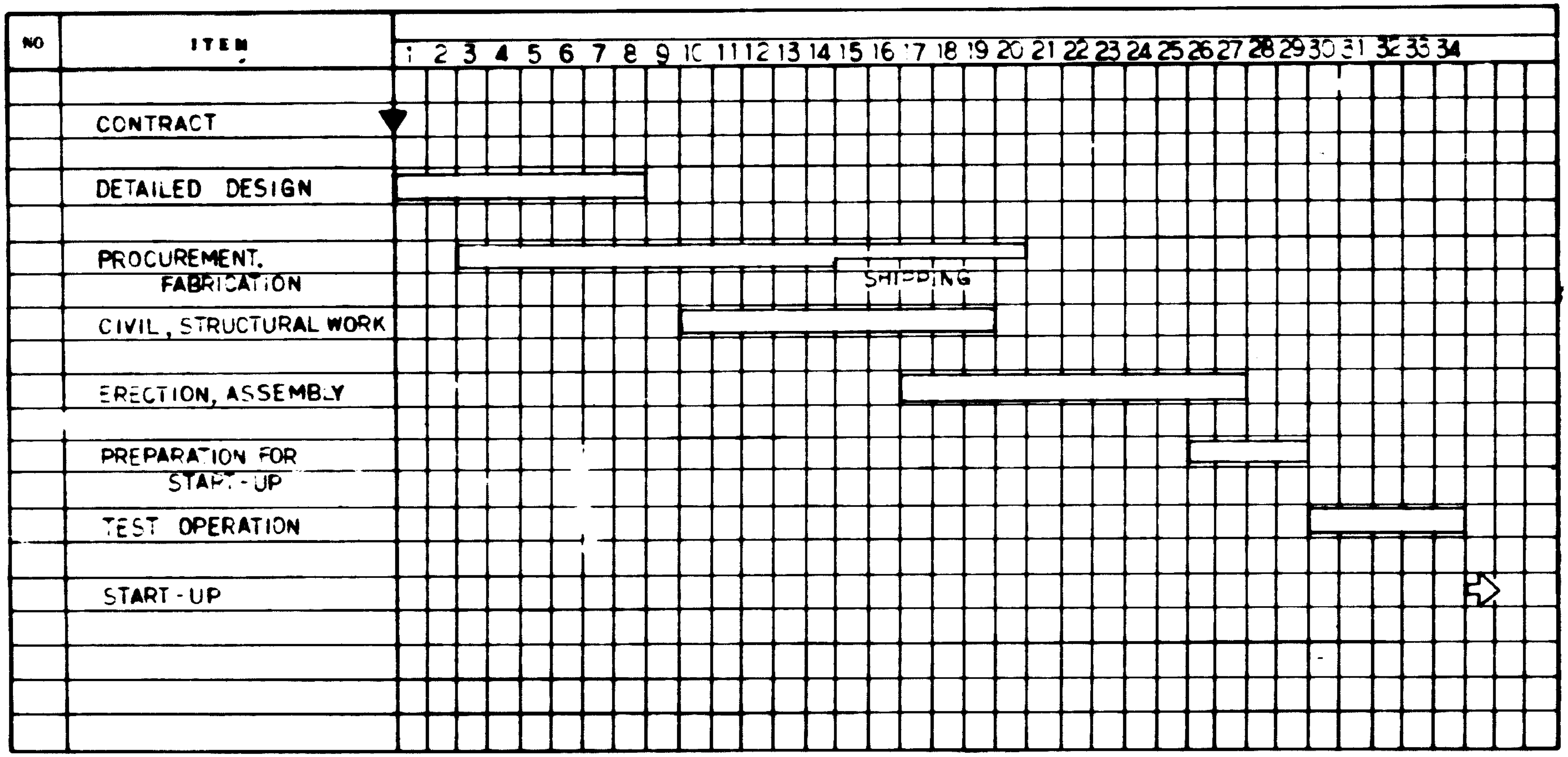
Equipment and materials, for which orders will have been laid during the detailed engineering period, reach the site and erection will start after the sixteenth month from the start of the project.

A peak of work load will be reached from the seventeenth to twentieth months when the structural steel will be built and major equipment erected.

Another peak period will be from the twenty-fourth to the twenty-sixth month, during which pipes will laid and electrical, insulation and painting work will be carried out.

At the end of the construction period, preparative work for start-up such as leak testing, drying of systems, running-in of machinery, calibration of instruments, catalyst loading, etc. will be started. From the thirtieth month, test operation will be started.

Fig. III-7 Construction Schedule



III-7 Personnel and Organization

An example of organization recommendable for successful operation of the BR factory is presented here. Fig.III-8 shows the organizational structure and required number of personnel as well as their qualifications. The whole factory, headed by general director, will consist of three departments, namely: Administration, Production, and Utility & Maintenance. The Sales Department will be organized separately from the factory.

a) Administration Department

This department will consist of the Administration, Accounting, Purchasing and Shipping Service Sections.

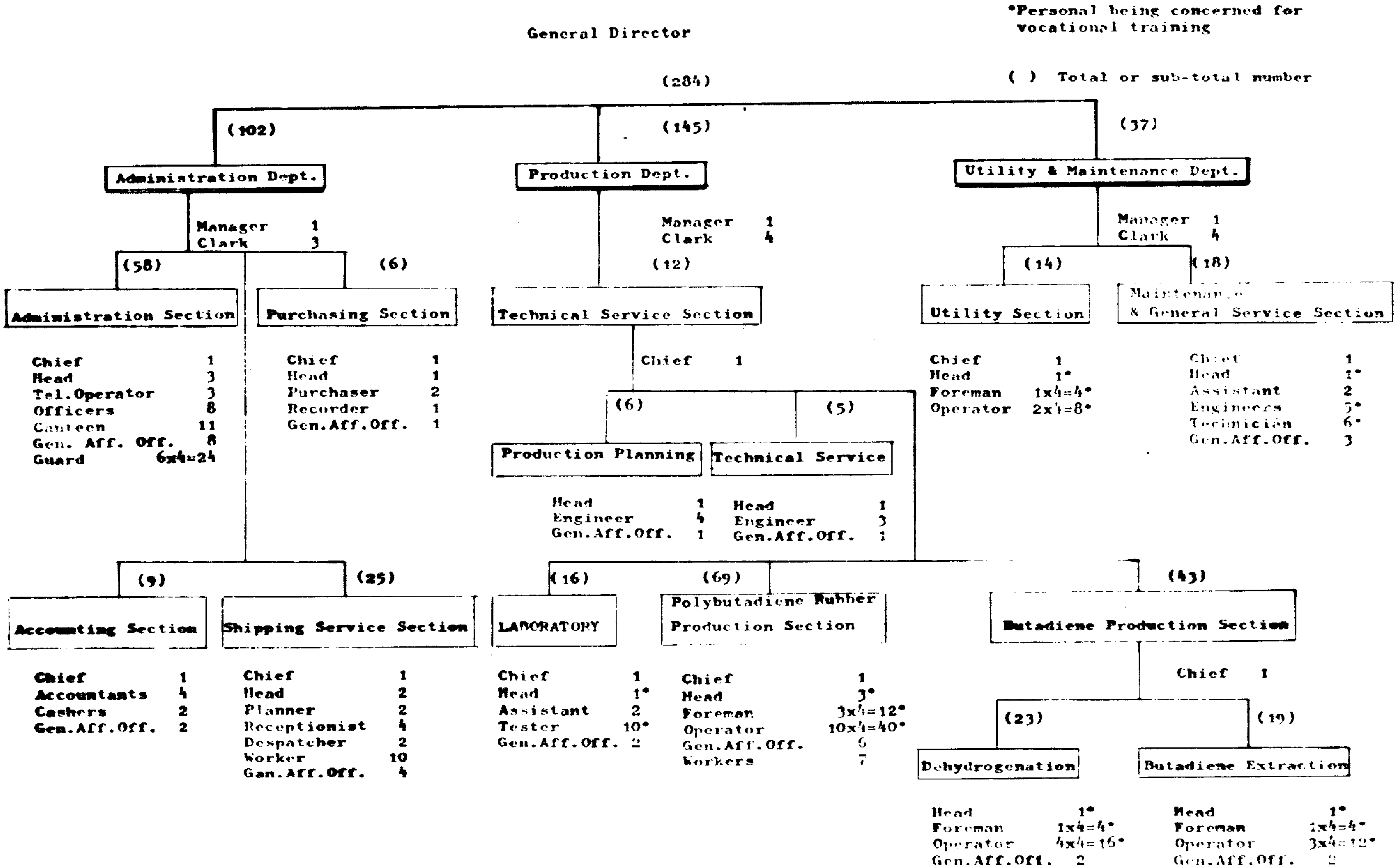
b) Production Department

This department will consist of the Production Planning, Technical Service, Butadiene Production, BR Production and Laboratory Sections, and will be responsible for production planning, technical services, plant operation with quality control and safety.

c) Utility & Maintenance Department

This department will consist of the Utility Section, and Maintenance & General Service Section. The latter section will be responsible for the daily maintenance.

Fig.III-8 Organization for Polybutadiene Rubber Plant



IV. Economic Study

IV-1 Capital Requirements

Capital requirements for the butadiene and BR plants are estimated on a 1976 basis and are broken down as shown in Table IV-1, 2 respectively.

Total capital requirements of this project on a 1976 basis are 93.26 Million US$ and broken down as shown in Table IV-3.

(1) Butadiene Production

Table IV-1 Capital Requirements for Butadiene Production

(Unit: 10^3 US$)

Basis	Product: Butadiene Process: Butane Dehydrogenation & Butadiene Extraction Capacity: 25,000 T/Y		
Items	Foreign Currency	Local Currency	Total
Investment			
Material & Equipment*	17,300	830	18,130
Engineering	6,140	-	6,140
Construction	8,250	7,460	15,710
Contingency	4,030	1,160	5,190
Royalty & Licence	2,410	-	2,410
Initial Charges of Catalyst & Chemicals	630	-	630
Start-up Expenses	790	-	790
Battery Limits	39,550	9,450	49,000
Offsite	4,610	1,920	6,530
Total Investment	44,160	11,370	55,530
Working Capital			1,460

*) Including Freight Cost and Spare Parts

(2) BR Production

Table IV-2 **Capital Requirements for BR Production**

(Unit: 10^3US$)

Basis	Product:	BR		
	Process:	Polymerization & Finishing		
	Capacity:	25,000 T/Y		
Items		**Foreign Currency**	**Local Currency**	**Total**
Investment				
Material & Equipment*		10,320	540	10,860
Engineering		3,520	-	3,520
Construction		5,230	3,590	8,820
Contingency		2,300	860	3,160
Royalty & Licence		1,720	-	1,720
Initial Charges of Catalyst & Chemicals		20	-	20
Startup Expenses		1,650	-	1,650
Battery Limits		24,760	4,990	29,750
Offsite		5,630	2,350	7,980
Total Investment		30,390	7,340	37,730
Working Capital				5,100

*) Including Freight Cost and Spare Parts

(3) Total Capital Requirements

Table IV-3 **Total Capital Requirements**

(Unit: 10^3 US$)

Item	Foreign Currency	Local Currency	Total
Investment			
Material & Equipment	27,620	1,370	28,990
Engineering	9,660	-	9,660
Construction	13,480	11,050	24,530
Contingency	6,330	2,020	8,350
Royalty & Licence	4,130	-	4,130
Initial Charges of Catalyst & Chemicals	650	-	650
Start-up Expenses	2,440	-	2,440
Battery Limits	64,310	14,440	78,750
Offsite	10,240	4,270	14,510
Total Investment	74,550	18,710	93,260
Working Capital			6,560

IV-2 Production and Sales Schedule

Based on the previous section "II-4 Conclusion" of "II. Product Selection", Production and Sales Schedule of the project is shown in Table IV-4.

Operating rate of this plant in the first year of its operation, 1981, will be 70% and 100% operation will be attained three years later, i.e., in 1984.

The sales values of the product, both for domestic and overseas markets are, as mentioned in the section "II-1 Synthetic Rubber Market", calculated on the basis of constant unit price of 820 $/T, throughout the project period.

Table IV-4 **Production and Sales Schedule**

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Production										
BR (T/Y)	17,800	20,700	22,400	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Sales										
Domestic										
Sales Amount (T/Y)	1,000	1,100	1,200	1,200	1,400	1,500	1,600	1,800	1,900	2,100
Sales Value (1,000$/Y)	820	900	980	980	1,150	1,230	1,310	1,480	1,560	1,720
Export										
Sales Amount (T/Y)	16,800	19,600	21,200	23,800	23,600	23,500	23,400	23,200	23,100	22,900
Sales Value (1,000$/Y)	13,780	16,070	17,390	19,520	19,350	19,270	19,190	19,020	18,940	18,780
Total Sales										
Total Sales Amount (T/Y)	17,800	20,700	22,400	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Total Sales Value (1,000$/Y)	14,600	16,970	18,370	20,500	20,500	20,500	20,500	20,500	20,500	20,500

IV-3 Production Cost

(1) Basis for Production Cost Estimation

Basis for production cost estimation on the project, on an actual 1976 basis, is shown in Table IV-5, which is based on data and information collected from the government offices of Kuwait (Ministry of Commerce and Industry, Shuaiba Area Authority, Ministry of Oil) and also from some companies both at home and abroad.

Table IV-5 **Basis for Production Cost Estimation**

1. Prices of Raw Materials	
a. Butane	120 $/T
b. Catalyst & Chemicals	73.8 $/T of Product
for Butadiene	13.8 $/T of Butadiene
for BR	60.0 $/T of BR
2. Prices of Utilities	
a. Electricity	0.33 ¢/KW
b. Process Water	18.33 ¢/m^3
c. Cooling Water	0.67 ¢/m^3
d. Natural Gas	18.10 ¢/MMKcal
e. Nitrogen	5.00 ¢/m^3

3. Salaries and Wages*

a. Manager	25,000 $/Y
b. Engineer	22,000 $/Y
c. Operator	10,000 $/Y
d. Labor	3,000 $/Y

*) Including Fringe Benefit

4. Annual Rental Fee on Land — 250 $/1,000m^2

5. Depreciation

a. Depreciation Method	Straight Line Method
b. Depreciation Period	10 Years
c. Salvage Value	0

6. Income Tax — Free

7. Financial Condition

a. Paid-in Capital	60% of Investment
b. Local Loan	40% of Investment
o Repayment Method	Repayment of principal in uniform installments
o Repayment Period	10 Years
o Interest	9%

(2) <u>Production Cost Estimation</u>

Production Costs of the product MR for each year are estimated based on Tables IV-1, -2 and -3, as shown in Table IV-6.

Table IV-6 Production Cost of [redacted]

(Unit: US$1,000)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Annual Production (T/Y)	17,800	20,700	22,400	25,000	25,000	25,000	25,000	25.000	25,000	25,000
Variable Cost										
Raw Materials	4,272	4,968	5,376	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Catalyst & Chemicals	1,314	1,528	1,654	1,846	1,846	1,846	1,846	1,846	1,846	1,846
Utilities	361	420	454	507	507	507	507	507	507	507
Sub-total	5,947	6,916	7,484	8,353	8,353	8,353	8,353	8,353	8,353	8 353
Fixed Cost										
Operating Labor & Supervision	2,465	2.465	2.465	2,465	2,465	2,465	2.465	2,465	2,465	2,465
Depreciation	9.326	9 326	9,326	9,326	9,326	9,326	9,326	9,326	9,326	9,326
Interest	1,865	1,679	1,492	1,305	1,118	931	744	557	370	187
Maintenance & Repairs	1,166	1,749	2,332	2,332	2,332	2,332	2,332	2,332	2,332	2,332
Property Tax & Insurance	933	933	933	933	933	933	933	933	933	933
Rental Fee on Land	94	94	94	94	94	94	94	94	94	94
Plant Overhead Cost	247	247	247	247	247	247	247	247	247	247
Sub-total	16,096	16,493	16,889	16,702	16,515	16,328	16,141	15,954	15,767	15,580
Factory Cost	22,043	23,409	24,373	25,055	24,868	24,681	24,494	24,307	24,120	23,933
General Expenses	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050	2,050
Production Cost	24,093	25,459	26,423	27,105	26,918	26,731	26,544	26,357	26,170	25,983
Unit Production Cost ($/T)	1,354	1,230	1,180	1,084	1,077	1,069	1,062	1,054	1,047	1,039

IV-4 Profitability

(1) Calculation of Cash Inflow

As can be noted from the figures in the left-hand three columns of Table IV-7, this project is to run in the red throughout the total period of projection.

Though the cash inflow would turn into a plus in the second year after start of operation, the total cash inflow over the entire study period is small as compared with the capital requirements.

Therefore, without any calculations, it is clear that this project is not economically feasible.

Table IV-7 **Calculation Result of Cash Inflow**

(Unit: US$1,000)

	Total* Capital Requirements	Total Sales Value	Total Production Cost	Income before Tax	Income Tax	Cash Inflow: Income after Tax	Cash Inflow: Depreciation	Cash Inflow: Total
1981	93,260	14,600	24,093	-9,493	0	-9,493	9,326	-167
1982		16,970	25,459	-8,489	0	-8,489	9,326	837
1983		18,370	26,423	-8,053	0	-8,053	9,326	1,273
1984		20,500	27,105	-6,605	0	-6,605	9,326	2,721
1985		20,500	26,918	-6,418	0	-6,418	9,326	2,908
1986		20,500	26,731	-6,231	0	-6,231	9,326	3,095
1987		20,500	26,544	-6,044	0	-6,044	9,326	3,282
1988		20,500	26,357	-5,837	0	-5,837	9,326	3,489
1989		20,500	26,170	-5,670	0	-5,670	9,326	3,656
1990		20,500	25,983	-5,483	0	-5,483	9,326	3,843
	93,260							24,937

*) As working capital can be redeemed when the project has been completed, investment costs alone are given as total capital requirements in this Table IV-7.

IV-5 Analysis of Production Cost

To determine the cause of nonprofitability of this project, a comparison has been made between the current world butadiene price of $350/T and the butadiene production cost at the first-stage butadiene production section of this project.

Given in Table IV-8 is the estimated average production cost of butadiene by this project on the assumption that the butadiene plant is operated at full capacity (i.e. 25,000 T/Y) throughout the 10-year project period.

Table IV-8 Production Cost of Butadiene

(Unit: US$1,000)

Items	Butadiene: 25,000T/Y
Variable Cost	
Raw Materials	6,000
Catalyst & Chemicals	346
Utilities	299
Sub-total	6,645
Fixed Cost	
Operating Labor & Supervision	822
Depreciation	5,553
Interest	611
Maintenance & Repairs	1,388
Property Tax & Insurance	555
Rental Fee on Land	47
Plant Overhead	82
Sub-total	9,058
Factory Cost	15,703
General Expenses	875
Annual Production Cost	16,578
Unit Production Cost ($/T)	663
International Price of Butadiene ($/T)	350

As can be seen, the butadiene production cost by this project comes to as high as $663/T, which is nearly double the recent international butadiene price of $350/T. This can be considered to be the primary reason for making this project non-profitable.

For reference purposes, Table IV-9 gives the average production cost of BR for a 10-year project period on the basis of 25,000 T/Y production using feed butadiene at a present international price of $350/T. The calculated cost of $795/T for BR is a little less than the present international price of $820/T, and this fact suggests that the cost of butadiene as intermediate product apparently has a harmful effect on the profitability of this project.

Table IV-9 Production Cost of BR (25,000 T/Y)

(Unit: US$1,000)

Items	Production Cost
Variable Cost	
Raw Material(Butadiene 350$/T)	8,750
Catalyst & Chemicals	1,500
Utilities	208
Sub-total	10,458
Fixed Cost	
Operating Labor & Supervision	1,643
Depreciation	3,772
Interest	415
Maintenance & Repairs	943
Property Tax & Insurance	377
Rental Fee on Land	47
Plant Overhead Cost	164
Sub-total	7,361
Factory Cost	17,819
General Expenses	2,050
Annual Production Cost	19,869
Unit Production Cost ($/T)	795
International Price of BR($/T)	820

IV-6 Capacity Increase of Butadiene Production Section

A larger butadiene production plant can provide economies of scale. Therefore, a study has been made for the cases where the butadiene production capacity of 25,000 T/Y is increased to (1) 50,000 T/Y and (2) 90,000 T/Y which is the world's largest scale at present. The results are indicated in the following Table IV-10.

Table IV-10 Production Cost of Butadiene

(Unit: US$1,000)

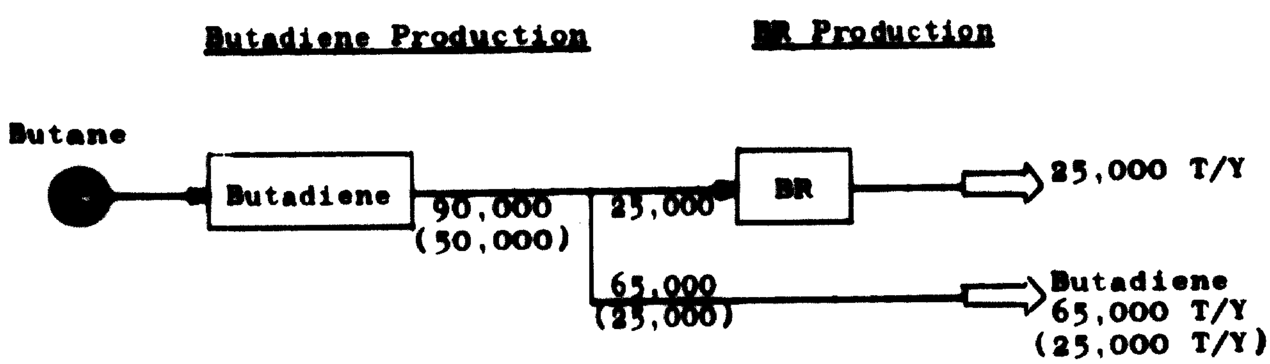
Items	Butadiene Production(T/Y)			Percentage to Production Cost (%)		
	25,000	50,000	90,000	25,000	50,000	90,000
Variable Cost						
Raw Material (120$/T)	6,000	12,000	21,600	38	45	51
Catalyst & Chemicals	346	792	1,246			
Utilities	299	598	1,076			
Sub-total	6,645	13,390	23,922	42	50	56
Fixed Cost						
Operating Labor & Supervision	822	822	822			
Depreciation	5,553	8,417	11,976	36	32	28
Interest	611	926	1,318			
Maintenance & Repairs	1,388	2,104	2,994			
Property Tax & Insurance	555	842	1,198			
Rental Fee on Land	47	47	47			
Plant Overhead	82	82	82			
Sub-total	9,058	13,240	18 437	58	50	44
Factory Cost	15,703	26,630	42,359			
General Expenses	875	1,750	3,150			
Annual Production Cost	16,578	28,380	45,509	100	100	100
Unit Production Cost ($/T)	663	568	506			

As is clearly noted from the foregoing table, the butadiene production cost by this project remains above the international price level even if the production capacity is raised to 90,000 T/Y. This suggests the fact that the high cost of butadiene in this project is attributable to the high cost of feed butane.

Incidentally, where the butadiene production capacity is increased to 50,000 T/Y or 90,000 T/Y, the plant will naturally create surplus butadiene as shown in Fig. IV-1 and this project cannot be viable unless these surplus can be sold outside.

Though the marketability of this surplus butadiene is outside the scope of this feasibility study, the following discussion assumes that it can be marketable at the international price.

Fig.IV-1 Block Flow for Increased Butadiene Production



IV-7 Effect of Price of Raw Material Butane

The following discussion is intended to determine the price level of feed butane at which this project can be viable.

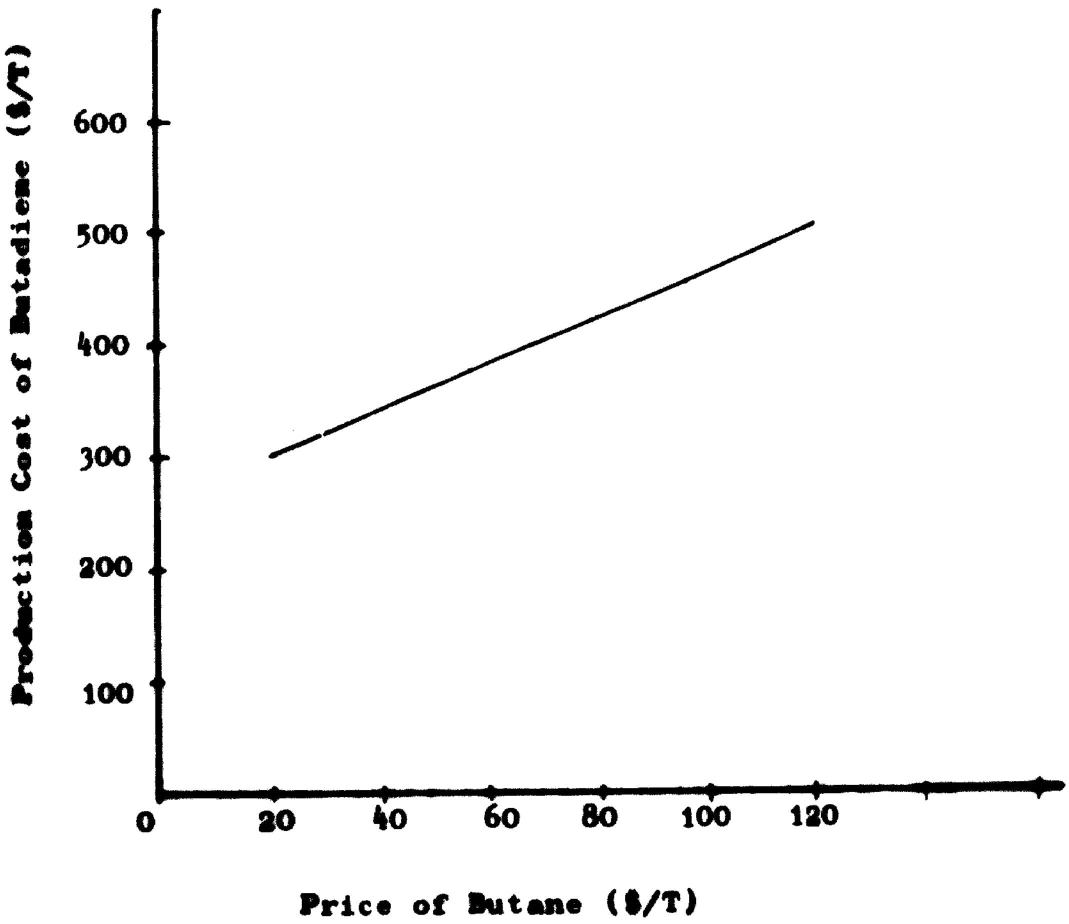
The figures assumed for this discussion are as follows:

Minimum required rate of return	5%
Production capacity of butadiene	90,000 T/Y
Products	
Butadiene	65,000 T/Y
BR	25,000 T/Y
Prices*	
Butadiene	350 $/T
BR	820 $/T

*) international price

Calculations based on these figures indicate that 30 $/T is the butane price that can both attain the minimum rate of return and provide butadiene and BR at international prices. As a reference, the butane price and butadiene production cost are plotted in Fig. IV-2.

Fig. IV-2 Effect of Butane Price



V. Recommendations

V-1 Vocational Training

(1) Personnel to be trained

One hundred and twenty-nine people who marked with asterisk in Fig. III-8 are concerned with vocational training.

(2) Qualification of Trainees

Following are recommended basic qualifications of trainees to be trained after recruitment.

a) Trainee as future engineer (or head):

Graduate of university, college or equivalent, more than 2 years' experience in an industrial firm is preferable.

b) Trainee as future foreman (chief operator):

Graduate of high school with more than 3 years' experience in similar industrial facilities such as petroleum refining or petrochemical or fertiliser plants.

c) <u>Trainee as future operator or technician:</u>

Graduate of high school or equivalent

(3) <u>Recommended Training Procedures & Curriculums</u>

a) Recruitment and selection of engineers & foremen should be done at an early stage of the field work commencement. It is expected that these engineers or foremen will play an important role in the site training for the operators and technicians

It is recommended that a minimum of three (3) months' training is to be provided for engineers and foremen at the butane dehydrogenation, butadiene extraction and BR plants which will be arranged by process licensers respectively.

In the training course, the following general instructions on plant management should be given for engineers and foremen.

<u>For engineers</u>:

a. General knowledge of the production plants (Processes included in a typical BR production, functional relation of each unit, etc.)

b. Organization for the production facilities
(Organization and function, manning plan and control, etc.)

c. Production management
(Production planning, cost accounting, schedule control, etc.)

d. Products control
(Storage and expedition, product quality control, etc.)

e. Safety control
(Safety measures, safety for works, pollution control, etc.)

f. Calculation drills

g. Maintenance planning

h. Observation of start-up & shut-down

<u>For foremen</u>:

a. General knowledge of the production plants

b. Training and supervision of operators

c. Data control and analysis

d. General knowledge of instruments

e. Safety control

f. Basic operating techniques of equipment

g. Practical training on actual process plant

h. Visit to equipment suppliers' factories
(pumps, compressors, heat exchangers, etc.)

As for instrument trainees, normally instruments suppliers are ready to provide such a training course and facilities within their own offices or factories to train those personnel who are concerned with plant operation and maintenance for instruments. So the most of the practical training can be conducted by utilizing such services.

b) <u>Training for operators and technicians (site training)</u>

Training for operators and technicians will take place at plant site. The following training curriculum and minimum training period are recommended.

a.	General explanation about the production facilities and products	1 week
b.	Instruction of basic operating techniques of equipment (Valve, rotating machine handling, instruments handling, etc.)	2 weeks
c.	Specific and intensive instructions on each process plant (P & I drawing study, initial start-up, shut-down, emergency procedures, instruction books study, pollution control, etc.)	3 weeks

d. Practical training at plant site — 12 weeks
(Witness hydraulic test, water flushing, instrumentation loop test, leak test, piping check, water circulation, dummy operation to emergencies, etc.)

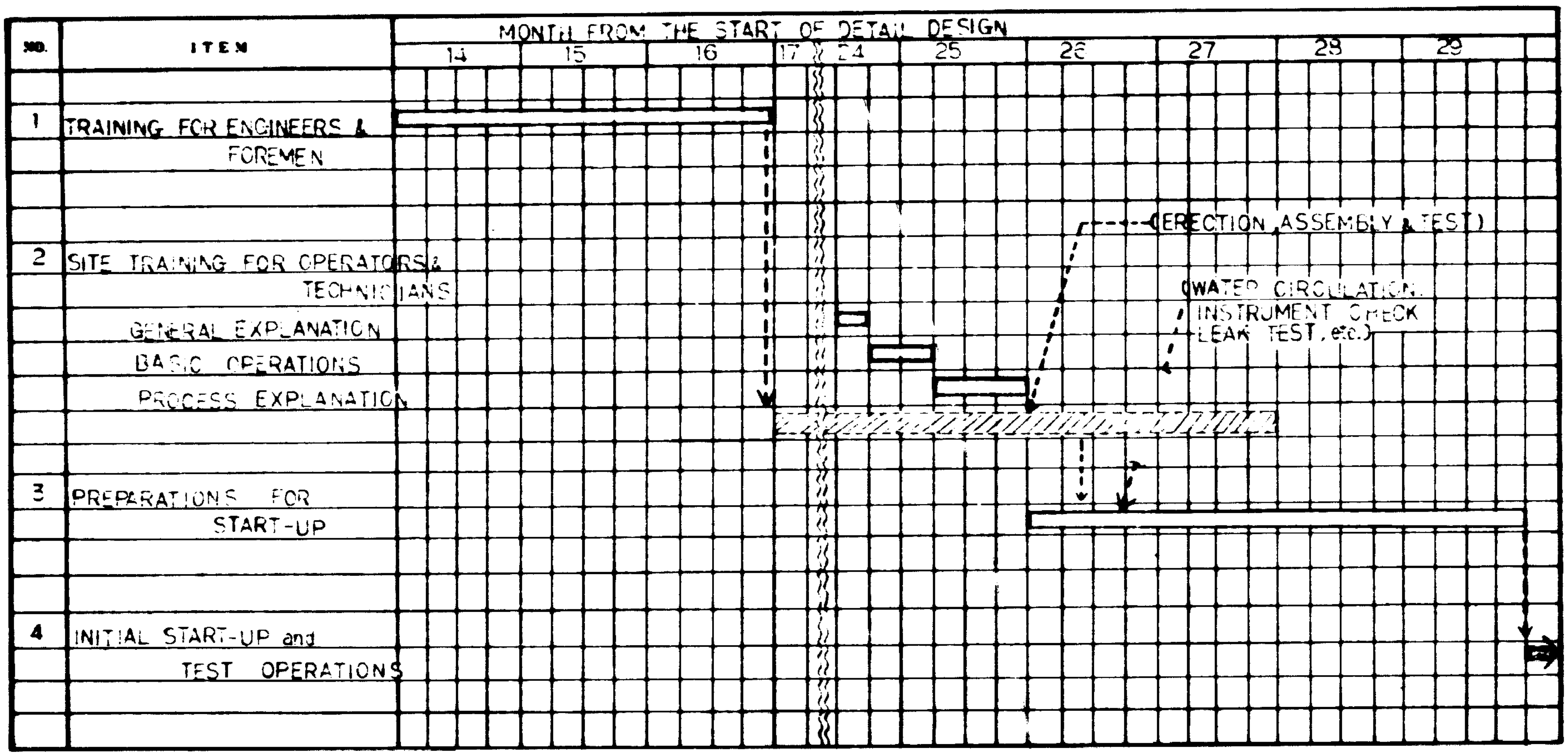
e. Initial start-up & performance test — 20 weeks

According to the above-mentioned training schedule, at least period of 18 weeks before the start-up should be secured for training.

Practical training at plant site is the period in which the upgrading of trainees' ability is highly expected. Therefore, stress should be placed on this period. Well-combined with construction schedule and well-coordinated training programs should be provided.

The time schedule for vocational training is shown in Fig. V-1.

Fig. V-1 **OVERALL TRAINING SCHEDULE**



V-2 Project Implementation

The result of the present study has indicated that the production of BR in Kuwait is infeasible under a given set of conditions.

This is mainly due to the high cost of butadiene, or of butane from which the butadiene is manufactured. But the above statement does not exclude all possibilities of providing BR in Kuwait.

As suggested in the alternative study, the project will become feasible if it is provided with butadiene feedstock at an international price, or if the raw material butane is supplied at a low price. It is dependent on a policy decision of the Government authorities concerned.

The following suggestion would be of use for consideration of the necessary steps for the implementation of the synthetic rubber project if the Government decides to proceed with the project.

(1) Setting-up of the implementing agency

An implementing agency for the project should be set up. Whether it may be one of existing Government authority, or a newly established organization, it should be fully authorized to make the necessary arrangements as below.

(2) Selection of a Partner

The agency, in cooperation with a consultant if necessary, should seek a partner who license technology, render technical and marketing assistance, as well as make financial contribution, if necessary, from among BR producers as listed in "III-3 Production Technology". Because manufacture and marketing of synthetic rubber requires much technical and commercial know-how, to secure the assistance of some established manufacturers who have sufficient capability and reputation is strongly recommended for a successful implementation of the project, especially where the project is of an export-oriented nature.

(3) Marketing Study

The agency, in cooperation with the partner as the case may be, shall study the following items in detail on the basis of, and as an extention of the market study carried out by the present study.

- Identify customers
- Confirm sales volume and price, as well as product specifications required
- Establish distribution channel

(4) Financial arrangements

The agency, in consultation with the partner as the case may be, shall take necessary measures to raise a fund required for the implementation of the project. The source of the fund may vary according to the situation. For example, it may be a capital and financial contribution of the partner, or it may be raised from domestic and/or international financial institutions, or it may be rendered by suppliers of the plant in the form of deferred payments.

(5) In-depth Project Study

The agency, in cooperation with the partner and/or a consultant as the case may be, should carry out an in-depth study of the project, which may consist of, but not necessarily limited to, the following items.

a) Engineering Study

- o Site definition by discussion with the Shuaiba

Area Authority

- o Process selection and definition

  While the process for BR production will be provided by the partner, other portion of the production processes, manufacture of butadiene, shall be selected based on a technical and trade information supplied by possible licensors of the respective process. Such information is likely of a confidential nature, so secrecy agreement will be necessary.

- o Preparation of engineering design basis

b) Economic Study

- o Confirmation of sales forecast based on the marketing study.
- o Firm estimation of production cost
- o Detailed economic evaluation of the project

The above three steps, namely.Marketing Study, Financial Arrangement, and Project Study, may be undertaken as a combined operation by a single body, which the partner is likely to be. It may be a convinient way to invite potential partner to provide their services to undertake such operations as above, and select the most favorable one as a partner.

(6) Selection of Contractor(s)

The agency, which conceivablly will be in close-tie up with the partner at this stage, should select a capable engineering-constructor to undertake the execution of the construction of the plant.

The contractor may be selected by nomination or by bidding. Though careful prequalification and examination of the contractor are necessary in the case of nominating, the period of construction will be significantly shortened by eliminating the bid procedure.

(7) Construction

The selected contractor perform detailed design, procurement and construction to finally achieve plant completion. In close cooperation with the partner, the agency needs to supervise such services of contractor to check whether they are accordant to the contract stipulations and project specifications.

The agency, if necessary, may trust a competent and experienced consultant with the supervising work in consultation with the partner.

Major management services are as follows:

- Inspection and approval of design drawings
- Inspection of procured equipment and materials
- Control of construction schedule
- Witnessing of mechanical tests of equipment
- Identification of performance
- Cost control

V-3 Marketing

The most of BR produced in the world is consumed by tire manufacturers and only a small portion of it goes to non-tire and non rubber industries. Those minor end-users are manufacturers of shoes, industrial goods, electric wires adhesive and high-impact resin.
The common grade of BR currently produced is non-oil rubber, and small quantities of oil extended rubbers, using naphthenic oil or highly aromatic oil are also produced.

Therefore, first of all, the tire industry, which consumes mainly non-oil BR, should be considered.
What is of prime importance in securing the BR market especially for tires is to maintain the guaranteed quality of products.

In most cases, tire manufacturers do not file a supplier's name in their purchase lists before confirming satisfactory product properties by conducting quality test which take a long period, for example three months to two years in some cases. Later, filed suppliers develop competition in terms of price and supplying conditions.
Therefore, for the creation of the BR industry in Kuwait, we recommend having a partner who has extensive experience in industry as mentioned in V-2.

Also many of the tire manufacturers are closely linked with respective rubber suppliers to maintain their product quality.

That is, the most of tire manufacturers purchase rubber of a previously determined grade.

In this respect, experience of the partner will also prove to be useful in identifying customers and confirming sales volume.

Secondly, the market for non-tire industry should take into account the expansion of future sales volume.

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