STUDY [illegible]

OF

IRAN JAPAN EXPORT REFINERY [illegible]

BOOK II; REPORT

[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY

STUDY

ON

IRAN-JAPAN EXPORT REFINERY

BOOK II: REPORT

March, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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INTRODUCTION

CHAPTER 1

INTRODUCTION

Book II covers the basic plan of the Iran-Japan Export Refinery Project and the findings of an economic analysis made on the basic plan.
The study is made for several cases of possible refinery sites, refinery configurations, and refinery capacities. Namely, four potential sites were selected on the basis of site surveys; two refinery configurations, that is, the hydroskimming type and the hydrocracking type; and three refining capacities, that is, 125,000 BPSD, 250,000 BPSD, and 500,000 BPSD are considered.
The economic analysis in this study calculates the average Ex-CTS (Central Terminal System) product cost in Japan by evaluating all the venture activities involved, including the petroleum refining in Iran, the product transportation from Iran to Japan, and the product storage in Japan.
This book is supplemented with a separately compiled Book III, "Supplement" which contains the study bases, such as surveys on site and transportation, outline of the facilities planned, and market survey.
It also reports on the economic analysis made on various alternatives.
As is evident from the above, this study report covers studies of external factors, ascertainment of the basic plan, and economic analyses, thus covering a wide range of factors to provide technical and economic information needed for realizing this venture on a commercial basis.

CHAPTER 2

SUMMARY

CHAPTER 2

SUMMARY

This chapter contains a summary of the study on the export refinery project to be implemented in Bushehr on the south coast of Iran, based on the target dates which are August 1, 1979 as the commencement of basic engineering works and 1983 as the commencement of commercial operation.

Further detailed report is presented in the subsequent chapters of this report and the separately compiled supplement volumes.

There are three main purposes of this study:

(1) To investigate possible refinery sites in the Bushehr area and analyze them to recommend the most suitable site for this project.

(2) To define all facilities to be included in this project in sufficient technical detail to enable the estimation of investment and operating costs to meet this study purpose.

(3) To estimate the costs and clarify the economic aspects of the project.

Some suggestions and recommendations are given at the end of this chapter for the further proceeding of this project.

REFINERY SITE

A detailed investigation is made on the following four candidate sites as marked on Figure 2.1, Site Location Map:

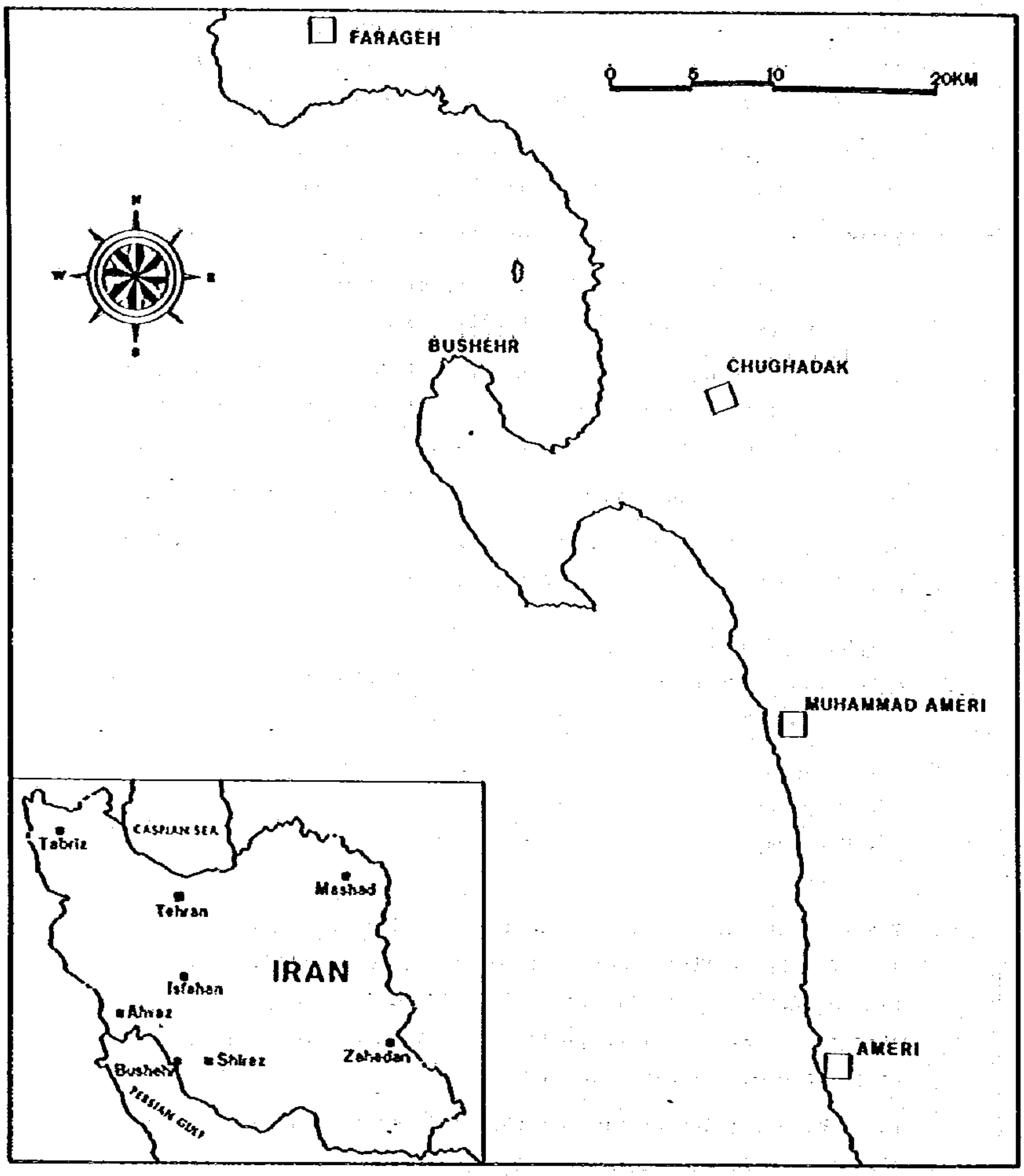
- Farageh
- Chugadak
- Muhammad Ameri
- Ameri

The investigation comes out that Muhammad Ameri will be the most suitable site for the refinery construction among these candidates. This judgement is made from an overall evaluation of tangible factors convertible to construction costs and intangibles such as easy access to Bushehr city and wide space of the hinterland.

The subsequent description of this chapter is made on the basis that the refinery is located at Muhammad Ameri.

Figure 2.1

Site Location Map



PROJECT OUTLINE

Number of cases investigated in this study are the following six cases covering two different refinery configurations and three refining capacities:

No.	Refinery Configuration	Refining Capacity
1.	Hydroskimming	125,000 BPSD
2.	Hydroskimming	250,000 BPSD
3.	Hydroskimming	500,000 BPSD
4.	Hydrocracking	125,000 BPSD
5.	Hydrocracking	250,000 BPSD
6.	Hydrocracking	500,000 BPSD

Outline of the project are as described below:

(1) Crude Oils and Products

50 percent Iranian light and 50 percent Iranian heavy crude oils are received at the Gurreh pump station and transported via separate pipelines to the refinery located at 165 Km far from the station. In the refinery, the crude oils are refined into the desired products for export to Japan.

Table 2.1 presents the salable products obtained from the refinery expressed in the percentage yields on crude. In addition, sulfur generated in the refining processes is recovered and shipped in a pelletized form.

Table 2.2 presents the annual shipment volume from the refinery.

(2) Installations

Installations of this project consist of crude oil pipeline, refinery facilities, and marine facilities. Major facilities planned for the respective six cases are shown in Table 2.3.

(3) Project Schedule

The time required for constructing these installations, from the start of basic engineering to mechanical completion, are estimated as follows:

Table 2.1

Products Yields

(Units: Vol% on Crude)

Products	Hydroskimming	Hydrocracking
Gasoline	10.0	10.0
Naphtha	9.9	12.5
Kerosene	14.1	17.4
Gas Oil	21.1	24.9
Low Sulfur Fuel Oil	28.2	20.6
Medium Sulfur Fuel Oil	7.0	5.1
Bunker Fuel Oil	3.0	3.0
Total	93.3	93.5

Table 2.2

Annual Shipment Volume

Case Description		White Oil 10^6Kl	Black Oil 10^6Kl	Sulfur 10^6Ton
Configuration	Capacity BPSD			
Hydroskimming	125,000	3.4	2.4	0.06
	250,000	6.8	4.7	0.11
	500,000	13.6	9.4	0.22
Hydrocracking	125,000	4.0	1.8	0.05
	250,000	8.0	3.5	0.11
	500,000	16.0	7.1	0.21

Table 2.3

Major Facilities

Configuration		Hydroskimming			Hydrocracking		
Refining Capacity, BPSD		125,000	250,000	500,000	125,000	250,000	500,000
	Unit	Capacity	Capacity	Capacity	Capacity	Capacity	Capacity
Major Process Units							
Atmospheric Crude Distillation	BPSD	125,000 x 1	125,000 x 2	125,000 x 4	125,000 x 1	125,000 x 2	125,000 x 4
Vacuum Flasher	BPSD	14,000 x 1	27,900 x 1	27,900 x 2	19,300 x 1	38,500 x 1	38,500 x 2
Naphtha Hydrodesulfurizer	BPSD	26,500 x 1	52,900 x 1	52,900 x 2	26,500 x 1	52,900 x 1	52,900 x 2
Catalytic Reformer	BPSD	9,700 x 1	19,300 x 1	19,300 x 2	9,700 x 1	19,300 x 1	19,300 x 2
Kerosene Hydrodesulfurizer	BPSD	17,700 x 1	35,300 x 1	35,300 x 2	17,700 x 1	35,300 x 1	35,300 x 2
Gas Oil Hydrodesulfurizer	BPSD	26,900 x 1	53,800 x 1	53,800 x 2	28,900 x 1	57,700 x 1	57,700 x 2
Vacuum Gas Oil Hydrodesulfurizer	BPSD	7,200 x 1	14,300 x 1	14,300 x 2	-	-	-
Vacuum Gas Oil Hydrocracker	BPSD	-	-	-	9,900 x 1	19,700 x 1	19,700 x 2
Atmos. Residue Hydrodesulfurizer	BPSD	34,900 x 1	69,800 x 1	69,800 x 2	30,300 x 1	60,600 x 1	60,600 x 2
Visbreaker	BPSD	-	-	-	9,400 x 1	18,800 x 1	18,800 x 2
Hydrogen Generator	$10^6 Nm^3/D$	0.83 x 1	1.66 x 1	1.66 x 2	0.55 x 2	1.10 x 2	1.10 x 4
Gas Treater/Sulfur Recovery	TPSD-S	90 x 2	180 x 2	180 x 4	90 x 2	180 x 2	180 x 4
Major Utility Systems							
Steam Generator	Ton/H	170 x 3	310 x 3	400 x 4	170 x 3	310 x 3	400 x 4
Power Generator	KW	14,000 x 3	16,000 x 4	19,000 x 6	15,000 x 3	17,000 x 4	21,000 x 6
Desalinator	Ton/D	2,400 x 3	4,700 x 3	9,100 x 3	2,700 x 3	5,200 x 3	10,200 x 3
Cooling Water System	Ton/H	18,000 x 1	17,000 x 2	17,000 x 4	20,000 x 1	19,000 x 2	19,000 x 4
Sea Water Intake System	Ton/H	5,000	10,000	20,000	6,000	11,000	21,000
Tankage	$10^3/Kl$	1,667	2,577	4,279	1,737	2,676	4,337
Products Loading Pipeline	-	Length 19 Km White Oil Products 32 in. x 3 lines, Fuel Oil 42 in. x 1 line, Potable Water 4 in. x 1 line, Ballast Water 22 in. x 1 line					
Sea Berth	-	Up to 200,000 DWT Single berth for 125,000 or 250,000 BPSD capacity, twin berth for 500,000 BPSD capacity					
Site Preparation	$10^6 m^3$	1.5	1.8	3.0	1.6	1.9	3.2
Harbor	-	Up to 10,000 DWT					
Crude Oil Pipeline	-	165 Km 16 in. x 2 lines	165 Km 20 in. x 2 lines	165 Km 26 in. x 2 lines	165 Km 16 in. x 2 lines	165 Km 20 in. x 2 lines	165 Km 26 in. x 2 lines

. Refinery

  - 125,000 BPSD and 250,000 BPSD : 44 months
  - 500,000 BPSD : 53 months

. Sea Berth : 36 months
. Harbor, Dredged Channel and Causeway : 33 months
. Crude Oil Pipeline

This estimation is made on the basis that the access way to the refinery and the refinery site will have been developed before the commencement of refinery construction.
The refinery will enter into on-stream within six months after the mechanical completion, hence the refinery could start its commercial operation at the 51st month for 1250,00 or 250,000 BPSD refinery and at 60th month for 500,000 BPSD counted from the date of commencement of basic engineering.

(4) Refinery Staffing

The organization structures and the department functions for the refinery operation are examined and based on which the required number of refinery employee is estimated.
It is estimated that the refinery with 125,000 or 250,000 BPSD capacity will require the permanent employee of about 650 - 680, while about 880 - 930 for 500,000 BPSD capacity.

COSTS

For the six base case refineries, the capital and operating costs are estimated. In the estimation, all costs are escalated and reflect economic conditions in Iran and expressed in US dollars.
Table 2.4 presents a summary of costs.
The above costs cover the refinery, products loading pipelines and sea berth.
The costs for the following facilities which would be developed as social and industrial infrastructures to support the refinery's activities are separately discussed:

. Crude Oil Pipeline
. Site Preparation
. Harbor, Dredged Channel and Causeway
. Housing for Refinery's Employee
. Access way connecting to the Refinery, etc.

Table 2.4

Costs Summary

Case Description		Capital Requirement 10^6US$	Operating Cost 10^6US$/Annum
Configuration	Capacity		
Hydroskimming	125,000 BPSD	1,074	55.2
	250,000 BPSD	1,499	76.4
	500,000 BPSD	2,446	129.6
Hydrocracking	125,000 BPSD	1,144	57.8
	250,000 BPSD	1,617	79.7
	500,000 BPSD	2,658	135.3

ECONOMIC ANALYSIS

In order to provide a guide information for further discussions and analysis, an economic analysis is conducted by means of a computer simulation and introducing a gross margin concept.

A required gross margin to ensure a certain level of profit is used as the criterion to evaluate various alternatives. The gross margin calculations are made for CTS to be located in Japan as well as for the refinery in Iran. The required average product price on an Ex-CTS in Japan 1983 basis is estimated as the summation of the following six items:

(1) Crude Oil FOB Price

Crude oil FOB price is based on the official sales price of Iranian light and heavy crude oils as of June 30, 1978. The average price is 12.65 US dollars per barrel.

(2) Refinery Margin

The required refinery margin to ensure ROE (DCF) of 11.8 percent is used. The margin is further broken down into the following four items for the purpose of presenting by what extent the individual element affects on the total gross margin:

- Operating costs: Direct operating costs per barrel of product on a mature year basis.

- Refinery fuel and losses: Loss of product resulted from refining operations; priced at crude oil costs.
- Cost of working capital: Interest on short-term loan covering working capital; expressed in US dollars per barrel of product.
- Capital recovery: Cost per barrel of product to recover the total fixed investment within the designated project life ensuring ROE (DCF) of 11.8 percent; defined to be the refinery margin less operating costs, loss, and cost of working capital.

(3) Bunker Fuel Oil Adjustment

Since bunker fuel oil is sold to product tankers directly in Iran and not transported to Japan as product, an adjustment is made to reach the required average price of products ex bunker fuel oil. The adjustment is made using bunker fuel oil price of 10.3 US$/barrel.

(4) Ocean Freight

The freight is based on tankers newly built in 1983 and transport distance of Kharg/Yokohama. The sizes of tankers are 130,000 DWT and 200,000 DWT for white oils and black oils respectively.

(5) Refined Product Import Tariff

Import tariff is calculated based on the Japan's import tariff rates being in effect as of June 30, 1978.

(6) CTS Margin

The required CTS margin to ensure ROE (DCF) of 11.8 percent is used. The margin is further broken down into the following three items and presented. The definition of each item is same as for the refinery margin discussed above:

- Operating costs
- Cost of working capital
- Capital recovery

The calculated results for the six base cases are summarized in Table 2.5. Besides, a reference is made to the average product value of product mix from the subject refinery evaluated by the assumed ex-refinery product prices in Japan, 1983.

SENSITIVITY ANALYSIS AND ALTERNATIVE STUDIES

In order to check the effects of changes in the major factors which are taken as bases to calculate required gross margins, sensitivity analyses are conducted for the following:

	Change Item	from	to
1.	Project Life	20 years	15 years
2.	Crude oil cost	12.65 \$/bbl	±5.0 \$/bbl
3.	Tax holiday	None	10 years
4.	Investment for industrical infrastructures	Not included	Included
5.	Construction cost	Base	±10 percent

The results of study are shown in Tables 2.6 and 2.7.

An analysis is also made for the effect on the ex-CTS product cost resulting from lowering the crude oil through-put level of the refinery Appendix 1 of Chapter 11.

Alternative studies enclosed in the volume 4 of Book III, Supplement evaluate attractiveness of the technical alternatives for the refinery design compared with base case refineries with 250,000 BPSD crude capacity. The alternative studies cover the following:

a. Utility Alternatives:

- Purchase electric power
- Purchase natural gas
- Purchase soft water

b. Fuel Oil Sulfur Alternatives

c. Process and other Alternatives:

- Mixed crude operation
- Different crude process ratio: IL: IH = 6:4
- Adoption of coker
- Less gasoline production: by 5% on crude
- No medium sulfur fuel oil production
- Utilize medium size tankers for product transport

The results of alternative studies show that the external utilities supply at an attractive price will have significant contributions on the refinery's economics.

Table 2.5

Required Average Product Price

(Unit : US$/BBL)

Items \ Configuration and Capacity	Hydroskimming 125,000 BPSD	Hydroskimming 250,000 BPSD	Hydroskimming 500,000 BPSD	Hydrocracking 125,000 BPSD	Hydrocracking 250,000 BPSD	Hydrocracking 500,000 BPSD
Crude Oil Cost (FOB)	12.65	12.65	12.65	12.65	12.65	12.65
Refinery Margin						
-Operating Costs	1.53	1.06	0.90	1.59	1.10	0.93
-Refinery Fuel and Losses	0.91	0.91	0.91	0.88	0.88	0.88
-Cost of Working Capital	0.23	0.17	0.14	0.23	0.17	0.14
-Capital Recovery	4.16	2.89	2.47	4.45	3.13	2.70
Subtotal Refinery Margin	6.83	5.03	4.42	7.15	5.28	4.65
Bunker Fuel Oil Adjustment	0.30	0.25	0.22	0.31	0.25	0.23
Ocean Freight (Refined Products)	1.73	1.73	1.73	1.75	1.75	1.75
Refined Product Import Tariff	0.90	0.90	0.90	0.95	0.95	0.95
CTS Margin						
-Operating Costs	0.40	0.29	0.24	0.40	0.29	0.24
-Cost of Working Capital	0.39	0.38	0.37	0.39	0.38	0.37
-Capital Recovery	1.49	1.15	1.00	1.49	1.15	1.00
Subtotal CTS Margin	2.28	1.82	1.61	2.28	1.82	1.61
(A) Ex-CTS Required Av. Product Price	24.69	22.38	21.53	25.09	22.70	21.84
(B) Av. Product Value in 1983, Japan	17.83	17.83	17.83	17.93	17.93	17.93
(B) - (A)	-6.86	-4.55	-3.70	-7.16	-4.77	-3.91

Note

1) The average product value in 1983, Japan is calculated using the existing refinery based ex-refinery product prices. In estimating product prices in 1983, a certain cost escalation through 1978 to 1983 is taken into account.

Table 2.6

Sensitivity Analysis
Change in Required Gross Margin
(Case 1 Hydroskimming)

Refining Capacity, BPSD	125,000	250,000	500,000
Required Gross Margin (US$/BBL) of Base Cases	6.83	5.03	4.42
Change in Required Gross Margin (US$/BBL)			
1. Project Life : 15 years	+0.43	+0.29	+0.28
2. Crude Cost : ±5 US$/BBL	±0.42	±0.41	±0.40
3. Tax Holiday : 10 years	-0.33	-0.24	-0.15
4. Scope : Including Infrastructure	+0.97	+0.59	+0.36
5. Plant Cost : ±10%	±0.46	±0.34	±0.27

Table 2.7

Sensitivity Analysis
Change in Required Gross Margin
(Case 2 Hydrocracking)

Refining Capacity, BPSD	125,000	250,000	500,000
Required Gross Margin (US$/BBL) of Base Cases	7.15	5.28	4.65
Change in Required Gross Margin (US$/BBL)			
1. Project Life : 15 years	±0.46	±0.33	±0.30
2. Crude Cost : ±5 US$/BBL	±0.41	±0.39	±0.39
3. Tax Holiday : 10 years	-0.36	-0.24	-0.16
4. Scope : Including Infrastructure	+0.97	+0.59	+0.37
5. Plant Cost : ±10%	±0.49	±0.36	±0.29

INFRASTRUCTURES

It will require the development of some industrial and social foundations to implement the refinery project in Bushehr area. The scope and schedule of such developments will be subject to concessive agreements between the Iranian government and a venture company.
In this respect, major elements may have to be discussed as infrastructures for the project are itemized and their requirements for the refinery to be constructed at Muhammad Ameri are discussed.

(1) Crude Oil Pipelines

- For transportation of the 500,000 BPSD crude oils, two pipelines with a 165 Km distance and 26 inches diameter will be required.
- The cost is estimated to be about 120 millions US dollars.
- The time required for the construction will be about 36 months and 6 months advanced completion to the refinery's startup will be required.

(2) Site Preparation

- For construction of the refinery with an ultimate capacity of 500,000 BPSD, approximately 4,000,000 m^2 of refinery area will be required and the earth work for developing the area will be about 3,000,000 m^3.
- The cost for the work is estimated to be about 20 millions US dollars.
- The time required for the development will be about 21 months.

(3) Harbor, Dredged Channel and Causeway

- For shipment of solid sulfur and bunker fuel oil, a harbor and dredged channel capable of accommodation up to 10,000 DWT carriers and a causeway of 3.5 Km long to connect the harbor with the refinery will be required.
- The total cost for constructing the facilities is estimated to be about 120 millions US dollars.
- The time required for the construction will be about 33 months.

(4) Community and Access Way to the Refinery

- It will be advantageous to develop a community for the refinery employees in Bushehr City, for which the area of about 220,000 m^2 will be required for 500,000 BPSD.

- Prior to the commencement of the refinery operation, an access way to reach the refinery branching from the existing trunk road to be developed. The asphalt paved road with eight meters width is estimated to cost about 15 millions US dollars.
- Besides the above, improvement of other social infrastructures is considered to be essential for the successfull implementation of the project.

RECOMMENDATIONS

In order to achieve the efficient and rapid realization of the refinery and the most beneficial return from the project, it is recommended that the following items should be discussed and defined at the early stage from now:

(1) Identification of policy issues to render the project economically attractive.

(2) Type and capacity of the first stage refinery.

(3) Refinery operation aspects.

- Service factor
- Product quality
- Flexibility
- Location of shipping terminal

(4) Product transportation

- Secondary transportation
- Contamination
- Direct transportation

(5) Joint venture company

(6) Scope of investment

- Infrastructure
- Product carrier
- CTS

(7) Funds - raising, supply and demand program.

(8) Comparison with Japan's expanded and grass roots refineries etc., to be constructed in future.

(9) Other items for project implementation.

CHAPTER 3

STUDY BASES

CHAPTER 3

STUDY BASES

This chapter describes the study bases that have been set for this study.

CRUDE OIL:

Type

- 50 percent Iranian Light and 50 percent Iranian Heavy.
- Crude oils will be made available either mixed or segregated.

Assay

- To be based on the following crude assays which are provided by NIOC for this study:

  Iranian Light Crude: Exxon, August 1971
  Iranian Heavy Crude: Exxon, December 1971

Pick-up Point

- Crude oils will be made available at Gurreh pump station at 900 psig pressure.

REFINERY:

Location

- Bushehr
- Four alternative sites in Bushehr area suggested by NIOC as some of the potential sites.
- Site comparison will be made including, but will not be limited to, those suggested by NIOC.

Refinery Capacity

- Three alternatives; 125,000, 250,000 and 500,000 BPSD.
- In calculating annual production rate, an overall on-stream factor of 85.0 percent will be used.

Configuration

- Two alternatives, namely, hydroskimming and hydrocracking.
- To maximize middle distillates for both cases.

Utilities

- Self-supporting.
- Alternative investigations will be made for the cases of receiving such external utilities as electric power, fresh water and natural gas based on NIOC's suggestion.

Tankage

- Crude oil tankage is set to have a capacity for 7 days.
- Other tankage will be set by taking into account the operation and product loading schedule of the refinery.

Pollution Control

- Intermediate abatement.
- No stack gas scrubbing but handle ship's deballasting water.

Code and Standard

- Internationally acceptable ones will be used.

PRODUCTS:

Product specification and product slate will be set taking into account that the products will be exported mainly to Japan's market.

PRODUCTS LOADING AND TRANSPORTATION:

Tanker Size

- Up to 200,000 DWT will be considered on the basis that a central terminal system (CTS) for products unloading will be built in Japan.
- Alternatively, the case of direct transportation by medium size tankers will also be studied.

Location of CTS

- Two alternatives, namely, northern and southern areas of Japan.
- Freight differential to be estimated.

Tank Capacity of CTS

- Inventory capacity of storage tanks in CTS will be determined taking into account the applicable laws and regulations of Japan.

HOUSING FOR REFINERY'S EMPLOYEE:

The study will not cover the estimation of housing for refinery's employee.

COSTS ESTIMATION:

Investment Cost

- Engineering and construction will be commenced on August 1, 1979.
- Escalation through construction period to be included.
- No import duties or sales tax on equipment.
- A nominal figure of 5 millions US dollars will be used for land cost.

Operating Costs

- Based on the wages and salary schedule from NIOC.
- Minimum manpower for permanent employee by introducing outside contract maintenance force for covering turnaround peaks.

CHAPTER 4

BASIC CONSIDERATIONS

CHAPTER 4

BASIC CONSIDERATIONS

This chapter describes the basic considerations made in planning the study. The assumptions which have been set to supplement those defined in the study bases are also included. The following are the contents of this chapter:

- Product Selection and Product Specifications
- Mathematical Model
- Maintenance Turnarounds and Intermediate Tankage
- On-stream Factor
- Product Loading
- Production Prevention

4.1 Product Selection and Product Specification

4.1.1 Product Selection

In selecting suitable product mix for an export oriented refinery, particular attentions should be paid for transportation economics, especially in the case that the anticipated market is located far from the refinery, likely to this project.

The products from the refinery will be transported to Japan by very large product carriers and distributed to consumers via CTS to be constructed somewhere in Japan. It is to be noted that the CTS could have a function, if required, of further blending to obtain the other grades of products and therefore, the product mix from the refinery will not require to meet exactly with the demand pattern in the market.

It will be advisable to reduce the numbers of product grades to be involved as far as practicable from the following viewpoints:

a. Number of product grades to be loaded on a product carrier should be limited to two or three at maximum due to contamination and complexity of operation reasons.
b. One shipment volume is very large and consequently required tankage to accommodate each grade of products to be loaded will become large.

c. Installation of product loading pipelines for common use will be limited due to contamination reason. In the case that a common loading pipeline is used to load different grades of product, lot size of each product should be large enough to minimize effect of interface oil between two grades on product qualities.

d. Therefore, the increase in numbers of product grades will result in the increase in requirements for tankage and loading pipeline installations.

In this respect, it will be advisable that the products selected for an export refinery will hold majority in the anticipated market.

The following grades of fuel products are presently marketed in Japan:

. Gasoline - premium and regular
. Naphtha
. Jet Fuel
. Kerosene
. Gas Oil
. A Fuel Oil
. B Fuel Oil
. C Fuel Oil

Of those, premium gasoline, jet fuel, and A and B fuel oils are planned to be not produced based on the following considerations:

Gasoline - Premium

It is anticipated that the demand for premium gasoline will decrease rapidly reflecting the strengthened regulations on automobile's exhaust gas qualities, (Refer to Table 4.1). Therefore, there is no positive reasons to produce a small quantity of premium gasoline in newly installed export refinery.

Jet Fuel

Since jet fuel is rather minor product in the market as shown in Table 4.2, jet fuel is not planned to produce. Of the two grades of jet fuels, namely, JP-4 (gasoline type) and JP-1 (kerosene type), JP-1 can be, if required, delivered from CTS in the expense of kerosene product.

Table 4.1

Demand Pattern of Motor Gasoline
(FY 1978 - 1982, Japan)

Grade	Octane Number	Fisical Year				
		1978	1979	1980	1981	1982
Premium	94	10%	8%	6%	5%	4%
Regular	90	90%	92%	94%	95%	96%

Note: 1) Octane number on a lead-free basis.
2) Source: The petroleum Supply Plan for FY1978 - 1982, prepared by the MITI.

A Fuel Oil

In general, production of A fuel oil is carried out by blending straight-run or hydrotreated gas oil with 2-3 percent of atmospheric residue. Therefore, the demand for A fuel oil is treated as that for gas oil, from the refinery's production planning viewpoints. In this connection, it is planned that the refinery delivers gas oil and further blending to obtain A fuel oil, if required, is carried out in the CTS in Japan.

On the other hand, since the price difference between gas oil and A fuel oil is rather small, it will be advantageous from the viewpoint of import tariff difference to import gas oil as A fuel oil rather than as gas oil.

However, since the above import tariff difference can be neglected provided that the blending on a bonded condition will be allowed, it will be advisable from the standpoint of freight costs and flexibility that oils to be assigned for A fuel oil production be transported separately as gas oil and fuel oil and blended in CTS following the demand.

B Fuel Oil

B fuel oil is not planned to produce due to the following reasons:

a. B fuel oil is rather minor product in the market and its demand is anticipated to decrease in future. (Refer to Table 4.2)

b. Most of consumers of B fuel oil are minor industries and generally do not have fuel oil storage and handling facilities with heating devices. Therefore, B fuel oil is needed to be of low pour point, i.e. 0-5°C. Meanwhile, atmospheric residue from Iranian crudes is rather of high pour point, approximately 28°C, and is not suitable to produce low pour point B fuel oil within its viscosity specification limits.

As for C fuel oil, only two grades with differents sulfur levels are planned to produce taking into account the transportation and storage economics and possible further blending to obtain other grades of products having any intermediate sulfur level.

4.1.2 Product Specifications

There are two kinds of product specifications, from refiners' veiw, namely, manufacturing and selling specifications.

In general, the manufacturing specification has a certain allowance over the selling specification to cope with possible quality deteriorations at distribution stage due to contamination, etc.

In this study, however, no attempt is made to such allowances provided that provision of such allowances will have no significant effect on the facility planning as well as on refinery's economics.

The Japanese Industrial Standards (JIS) specifies the minimum requirements for qualities of petroleum products. The prevailing refiner's specifications have certain margins over those of JIS generally. Taking into account such facts, the product specifications for this study are set as shown in Table 4.3.

The following describes briefly the considerations made in setting up the specifications:

Table 4.2

Demand and Supply Pattern of Petroleum Products

(FY 1978/1982, Japan)

	1978						1982					
	Supply			Demand			Supply			Demand		
	Production	Import	Total	Domestic	Export	Total	Production	Import	Total	Domestic	Export	Total
Gasoline	13.52	-	13.52	13.48	-	13.48	12.24	-	12.24	12.22	0.02	12.24
Naphtha	10.98	3.71	14.69	14.81	-	14.81	12.57	2.01	14.58	14.58	-	14.58
Jet Fuel	1.66	0.06	1.72	0.99	0.76	1.75	1.71	0.06	1.77	0.99	0.78	1.77
Kerosene	9.83	-	9.83	10.13	0.01	10.14	9.59	-	9.59	9.59	-	9.59
Gas Oil	7.69	-	7.69	7.80	0.01	7.81	7.50	-	7.50	7.48	0.02	7.50
A Fuel Oil	7.81	1.28	9.09	8.61	0.62	9.23	7.82	1.08	8.90	8.28	0.62	8.90
B Fuel Oil	3.24	-	3.24	3.26	0.02	3.28	2.53	-	2.53	2.51	0.02	2.53
C Fuel Oil	37.77	4.76	42.53	35.95	6.64	42.59	38.54	3.90	42.44	35.98	6.46	42.44
Total Fuels	92.50	9.81	102.31	95.03	8.06	103.09	92.50	7.05	99.55	91.63	7.92	99.55

1978:

Crude Through-put: 4,180,700 BPCD

Naphtha Demand:
- Petrochemical use 497,400 BPCD
- Gases & Fertilizer use 77,300 BPCD
- Fuel use 44,700 BPCD
- Total 619,400 BPCD

1982:

Crude Through-put : 5,138,700 BPCD

Naphtha Demand:
- Petrochemical use 608,000 BPCD
- Gases & Fertilizer use 96,800 BPCD
- Fuel use 44,700 BPCD
- Total 749,500 BPCD

Note.

1. Figures shown in this table indicates supply/demand values in percentages on crude oil processed in refineries.
2. Source: Petroleum supply plan for FY 1978 - 1982, prepared by the MITI.

Table 4.3

Product Specification Summary

Products	Properties	Specification
Gasoline	RON, F-1 Clear RVP @37.8°C ASTM Distillation (D-86) 10% 50% 90% 97%	Min. 90 0.45 - 0.63 Kg/cm^2 Max. 65 °C Max.120 °C Max.180 °C Max.205 °C
Naphtha	RVP @37.8°C Sulfur Content EP	Max. 0.63 Kg/cm^2 Max. 0.01 wt.% Max. 200 °C
Kerosene	Flash Point (Tag) Smoke Point Sulfur Content ASTM Distillation (D-86) IBP 95%	Min. 40 °C Min. 24 mm Max. 0.005 wt.% Min.150 °C Max.235 °C
Gas Oil	Flash Point (P-M) Pour Point Cetane No. Sulfur Content ASTM Distillation (D-86) 90%	Min. 50°C Max. -7.5°C Min. 50 °C Max. 0.1 wt.% Max.350 °C
L/S Fuel Oil	Flash Point Sulfur Content Viscosity @50°C	Min. 60 °C Max.0.1 wt.% Max.150 cSt
M/S Fuel Oil	Flash Point Sulfur Content Viscosity @50°C	Min. 60 °C Max.1.5 wt.% Max.150 cSt
Bunker Fuel Oil	Sulfur Content C.C.R. Viscosity @50°C	Max.3.5 wt.% Max. 12 wt.% Max.250 cSt

Motor Gasoline - Regular

Lead free gasoline with research octane number of 90 is presently marketed in Japan and the octane rating requirement is anticipated to remain unchanged in near future.

The JIS specification for motor gasoline allows alkyl-lead addition by 0.3 ml/l. However, automobiles equipped with catalyst type exhaust gas converter are prevailing recently and they do not allow alkyl-lead.

In this connection, the octane rating requirement of RON 90 on a lead-free basis is set.

As for vapor pressure limit, 9.0 psi (0.63 kg/cm) max. is used taking into account that the refinery is located in a hot zone.

On the other hand, a target of aromatics and olefins contents in motor gasoline has been setup recently in connection with the automobiles exhaust gas control program as follows:

Aromatics	35 vol. % max.
Olefins	10 vol. % max.

Reformate based motor gasoline with research octane number of 90 would contain aromatics slightly exceed 35 vol. % and, in such a case, FCC unit with relatively small capacity will have to be installed to satisfy the requirement.

However, no attempt is made to this aspect in this study, provided that motor gasoline containing aromatics slightly exceed the above limit would be acceptable and provision of FCC unit, if installed, will not have significant effect neither on refinery's economics nor product slate.

This will be subject to further discussion at an early stage of execution.

Naphtha

No special consideration is made for the naphtha specifications. Reid vapor pressure limit is set taking into account the storage in hot climate.

Kerosene

Smoke point specification is set as 24 mm minimum against the JIS specification of 23 mm minimum. A target figure of 25 mm is prevailing in Japan's refiners, but it is difficult to obtain kerosene with 25 mm smoke point from 50%/50% mixture of Iranian light and Iranian Heavy crude oils without installing a smoke point improver. Therefore, only 1 mm margin against the JIS specification is considered. No additional specification required to meet the jet kerosene (JP-1) specifications is considered at this stage, although there is a possibility to deliver kerosene as JP-1.

Gas Oil

Gas oil specifications are set referring the prevailing figures in the current market. The lowest side figure is used for sulfur content. Many grades of gas oil in terms of pour point are marketed in Japan. Gas oil with lower pour point is appreciated in the market. In this study, a pour point limit of $-7.5^{o}C$ max. is used taking into account that this grade of gas oil hold a majority in the market.

C Fuel Oil

Many grades of C fuel oil with sulfur contents ranging 0.1 wt.% to 3.0 wt.% with the pitch of as small as 0.1 wt.%. It is thought that growth in demand for 0.1 - 0.3 wt.% S low sulfur fuel oil and 1.5 - 2.5 wt.% S medium sulfur fuel oil will be high in the future market compared with the other grades of fuel oil. In this study, 0.1 wt.% for low sulfur fuel oil and 1.5 wt.% S for medium sulfur fuel oil are set taking into account the anticipated ease of marketing in fugure, although these are rather extreme side figures compared with those prevailing in the present market.

The final selection of sulfur grades for fuel oil will be subject to a venture company's judgement with due consideration of the market conditions and economics.

A reference is made in Table 4.4 for C fuel's demand by sulfur grades.

Bunker Fuel Oil

The bunker fuel oil specifications are set referring those for 1,000 seconds viscosity (Redwood-I, @$50^{o}C$) bunker fuel oil.

4.2 Refinery Mathematical Model

There are two alternative refinery configurations in this study, which are hydroskimming and hydrocracking.

In the course of establishment of these refinery configurations, a mathematical model using linear programming techniques is developed to obtain suitable refinery balances.

Table 4.4

C Fuel Oil Demand Pattern by Sulfur Grade

(FY 1976 - 1981, Japan)

Fisical Year	1976	1977	1978	1979	1980	1981
Under 0.15 wt% S	1.2%	3.3%	3.1%	3.6%	3.9%	5.1%
0.15 - 0.25 wt% S	0.6%	0.5%	0.3%	0.3%	0.8%	0.3%
0.25 - 0.30 wt% S	14.4%	19.6%	17.8%	16.2%	15.8%	16.0%
0.3 - 0.5 wt% S	7.2%	8.6%	9.1%	8.7%	8.6%	8.9%
0.5 - 1.5 wt% S	18.0%	12.5%	11.9%	8.7%	11.7%	11.4%
1.0 - 1.5 wt% S	10.4%	6.7%	6.8%	10.0%	6.9%	7.0%
1.5 - 3.0 wt% S	48.2%	48.8%	51.0%	52.5%	52.3%	51.3%
Average Sulfur	1.49 Gt% S	1.46 wt% S	1.52 wt% S	1.56 wt% S	1.54 wt% S	1.52 wt% S

Source: The investigation carried out by the MITI.

The major considerations made in establishing the configurations are briefly discussed below:

<u>Crude Oils</u>

Taking into account the two alternatives of crude oil supply conditions, namely, segregated and mixed bases, crude oil data are prepared for the three different crude oils which are 100 percent of Iranian light crude oil, 100 percent of Iranian heavy crude oil and 50/50 percent mixture of both crude oils.

The cutting ranges of these crude oils are selected so as to meet the requirements stated in Chapter 3, Study Bases, as follows:

- The naphtha/kerosene cut point is set at 154°C to maximize kerosene within flash point limit.
- The kerosene/gas oil cut point is set at 235°C in view of smoke point limit for kerosene.
- The gas oil/residue cut point is set at 371°C to maximize gas oil.

Products

The product slate is obtained from the solution of the computer program which is processed under a consistent set of the following premises:

- The production rate of gasoline is fixed at 10 percent on crude. This figure is tentatively set based on a preliminary market forecast referring the Petroleum Supply Plan for FY 1978 - 1982 prepared by the MITI. Sensitivity analysis will cover the case for a different gasoline production rate.
- The production rate of bunker fuel oil is fixed at 3 percent on crude based on the estimated bunker fuel oil consumption of VLCC for round trip from Iran to Japan.
- The production ratio of low sulfur (0.1%S) and medium sulfur (1.5%S) fuel oil is fixed at 4:1. The sulfur level of C fuel oil pool (0.38%S) will meet the SOx control program in Japan after 1985 without help of stack gas scrabbing. Therefore, this case is considered to represent an extreme case. The cases for producing C fuel oils with different sulfur levels will be examined in alternative studies.
- The yields of other products are defined from the computer output so as to maximize middle distillates.

Process Units

All of the process units considered for this study have a proven record with several plants in successful commercial operation. No contact with process licensors, such as for catalytic reforming, residue hydrodesulfurizing, and hydrocracking processes, was made specific to this study.

The technical and economic data for these processes are based on those from our accumulated data file. The major process considerations are as follows:

a. Atmospheric Residue Hydrodesulfurizer

Since the atmospheric residue from Iranian heavy crude oil is of high in metal contents and deteriorates HDS catalyst rapidly, its minimum processing for the unit is considered.
By high-pressure hydrogen treating, the residue is desulfurized to be 0.1 weight percent fulfur. Reactors for the unit are considered to be designed on semi-annual basis.

In the range of 9 percent on feed of cracked gas oil produced from the unit is planned to be used as flushing oil for the fuel oil loading submarine pipeline when it is not in service.
Since the flushing oil requirements are almost equivalent to the cracked oil produced and the flushing oil is eventually shipped as fuel oil, the refinery balances are developed on the basis that no cracked as oil is routed to product gas oil pool.

The properties of cracked gas oil are estimated as follows:

Nominal Cut Point	190 - 343°C
Gravity, °API	36
Sulfur, wt.%	0.05
Cetane No.,	40 - 42
Color, ASTM	2

As is observed from the above, the cracked gas oil alone does not meet the specification in terms of cetane number and is needed to be blended with the majority of high cetane number component when it is planned to deliver as specification gas oil.

b. Hydrocracker

The hydrocracker is designed to be for the maximum middle distillates. The extensive recycle of fractionator bottom is made to extinguish it.

c. Catalytic Reformer

Hydrotreated heavy naphtha is processed to produce high octane number reformate for gasoline blending. The design octane number of RON 98 is used.

4.3 Maintenance Turnarounds and Intermediate Tankage

A grouped maintenance with the following operating schedule is considered in view of reducing peak time maintenance force:

a. Major maintenance shutdown

Once a year and for 30 days.

b. Catalyst replacement of atmospheric residue HDS (AR HDS)

Twice a year and for 15 days each; once of the twice replacement can be performed during major maintenance shutdown period.

c. Catalyst regeneration of catalytic reformer

At reasonable intervals and for a week.

d. Decoking and catalyst replacements for the units other than AR HDS

To be performed during major maintenance shutdown period.

e. Operating level

When one group is shutdown for maintenance, the other group is to be operated basically at 60 percent load.

f. Grouping for scheduled maintenance

The grouping as shown in Table 4.5 is considered. For 500,000 BPSD crude capacity, there are four groups.
Gas treating and sulfur recovery units have two trains each for one crude processing train.

Table 4.5

Grouping for Scheduled Maintenance

Group A	Group B
No.1 & 2 Atmos. Crude Units	Kerosene HDS
Vacuum Flasher	Gas Oil HDS
Gas Recovery	AR HDS
Naphtha Hydrotreater	No.1 H2 Generator
Catalytic Reformer	No.1 Gas Treater
VGO HDS	No.1 Sulfur Recovery
No.2 Gas Treater	
No.s Sulfur Recovery	
Foul Water Stripper	
(VGO Hydrocracker)*	
(Visbreaker)*	
(H2 Generator No.2)*	

Note: * For Case 2 Hydrocracking; VGO HDS will be eliminated.

Based on the above maintenance and operating schedule, tankage criteria for process intermediate services are set as follows:

AR HDS Charge	18 days
Kerosene HDS Charge	18 days
Gas Oil HDS Charge	18 days
VGO HDS (or Hydrocracker) Charge	7 days
Visbreaker Charge	7 days

A 15 percent safety factor is provided for all tanks.
No intermediate tankage specific to catalytic reformer charge is provided, because sufficient storage capacity to cover catalyst regeneration and re-startup is secured by the tanks provided for heavy naphtha before blending.

At 500,000 BPSD crude capacity, kerosene and gas oil HDS charge tanks can be reduced to one-half capacity, provided that kerosene and gas oil HDS units for another 250,000 BPSD train will not be shutdown for maintenance simultaneously.

While, AR HDS charge tanks could scarcely be reduced, because a certain space has always to be kept to cover shutdown for catalyst regeneration and unbalance between normal output from crude unit and AR HDS design capacity.

4.4 On-stream Factor

The major governing factors of on-stream factors for process units will include, among others, the losses in operation due to the following:

a. Scheduled shutdown for major maintenance.
b. Unscheduled shutdown due to troubles or minor maintenance, etc.
c. Forced shutdown or reduced operation due to the intermediate tankage limits.
d. Reduced operation due to having excess capacity against the demand.

Of those, items a through c above are taken up and attainable on-stream factors from the technical standpoints are briefly examined below.

The definition of on-stream factor used in this text is as follows:

$$\text{On-stream Factor (\%)} = \frac{\text{Annual Av. Through-put (BPCD)}}{\text{Design Capacity (BPSD)}} \times 100$$

Average Shutdown Periods

Table 4.6 presents the average shutdown periods due to technical reasons for the 1973-1977 period, Japan.

As is observed from the above table, average shutdown periods for the scheduled maintenance of distillates treating processes fall in one month and in the range of 4-5 days shorter for atmospheric crude unit.

However, in the case of adopting a flow scheme that unstabilized whole straight-run naphtha from an atmospheric crude unit is routed directly to a naphtha hydrotreater, shutdown period for scheduled maintenance of the crude unit will have to be governed by the downstream unit.

In this connection, the scheduled maintenance period of one month for the crude units and distillates processing units is used.
An allowance of 4 days per annum for unscheduled shutdown is also used.

Meanwhile, the scheduled and unscheduled shutdown periods for atmospheric residue hydrodesulfurizer are set for 40 days and 10 days respectively.

Attainable On-stream Factors

On the basis of the shutdown periods setup above and the grouped maintenance schedule and intermediate tankage as discussed in paragraph 4.3, the attainable on-stream factors are examined taking the atmospheric crude unit as the representative of one group, while the atmospheric residue hydrosulfurizer for the other.

Additional assumptions used are:

a. Atmospheric residue from the crude unit is totally routed to the atmospheric residue hydrodesulfurizer (AR HDS) and is not routed to the others except for AR HDS charge intermediate tanks.

b. The space of AR HDS charge tanks is totally usable for balancing feedstock including the additional space provided for safety. Then, the usable space becomes for 21 days' normal output of the crude unit.

$$18 \text{ days} / 0.85 = 21 \text{ days}$$

c. The AR HDS is oversized by 6.3 percent against the normal output of residue from the crude unit based on assumed on-stream factors of 85 percent and 80 percent for the crude unit and AR HDS respectively.

$$85\% / 80\% = 1.063$$

Table 4.6

Average Shutdown Period (1973-1977, Japan)

(Unit: days/year)

	Scheduled Maintenance			Unscheduled Shut-down		
	Min.	Max.	Average	Min.	Max.	Average
Crude Unit - Atmos.	19.0	33.3	27.2	1.0	4.4	2.6
Crude Unit - Vacuum	25.3	34.6	31.3	1.4	9.6	4.2
Catalytic Reformer	23.9	36.0	32.1	2.3	5.8	3.9
Naphtha HT	20.2	37.5	31.4	1.2	4.6	3.1
Distillate HDS	27.1	34.5	31.1	2.8	7.7	4.8
VGO HDS	30.1	42.6	38.4	2.8	19.8	9.8
Atmos. Residue HDS	42.8	54.5	48.1	0.2	38.3	11.9

Source: The investigation by the Petroleum Association of Japan.

d. Unscheduled shutdowns occur dispersally throughout operating period. Two cases, namely, one year and two years between major maintenance shutdown are examined as presented in Figures 4.1 and 4.2.

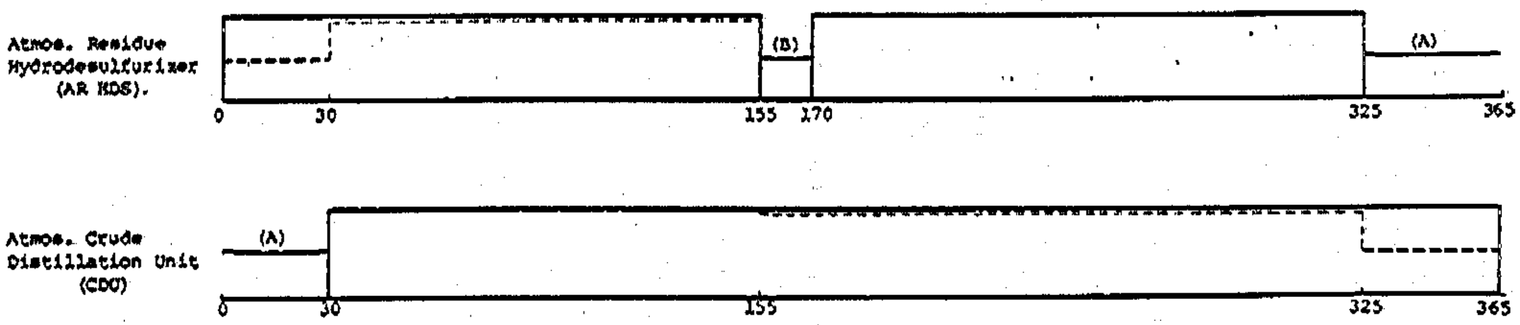
The resulting on-stream factors are as follows:

	One Year Continuous Operation	Two Years Continuous Operation
Crude Unit	83% (303 days)	90% (648 days)
AR HDS	78% (285 days)	83.5% (610 days)

Based on the above results and provided that a few percent improvement in on-stream factors will be possible by shifting a portion of atmospheric residue assigned for AR HDS to the vacuum flasher during the AR HDS's maintenance and vice versa, technically attainable on-stream factor of 80 percent for AR HDS and 85 percent for others are adopted taking a maintenance schedule of once a year as base.

Figure 4.1

Attainable On-stream Factors : Case-1 One Year Between Major Maintenance



(A) Maintenance
(B) Catalyst Replacement (15 days)

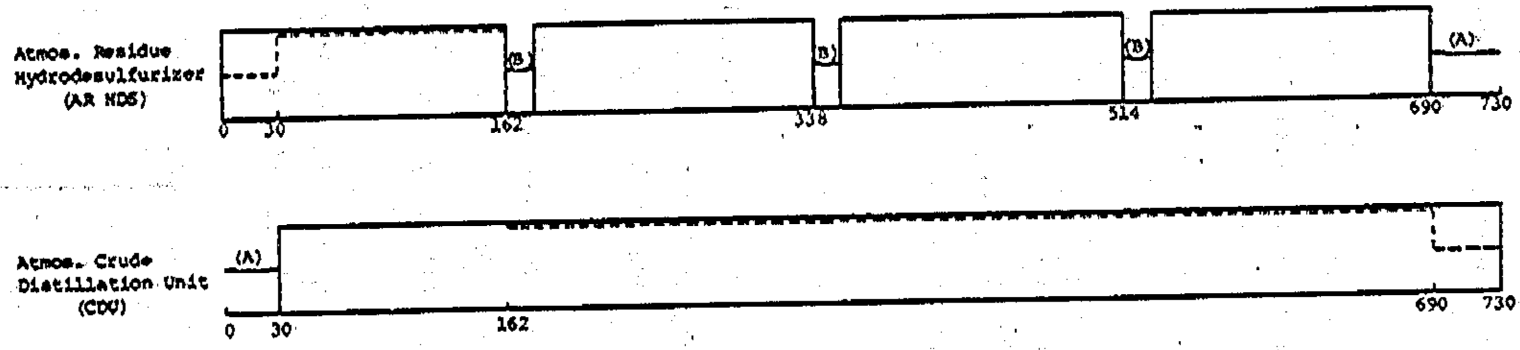
Period	Max. Operable Days W/O Tankage Limit		Loss in Operation Due to				Net Operable Days Attainable		Atmos. Residue Balance			
			Tankage Limit		Unsched. Shutdown				Supply		Uses	
	CDU	AR HDS	CDU	AR HDS	CDU	AR HDS	CDU	AR HDS	to AR HDS	to Tank	from CDU	from Tank
1 - 155th day	125	165	0	16	2	5	123	144	123	0	123	21
156 - 365th day	210	165	30	0	2	6	180	159	159	21	159	0
Whole Period	335	(310) 330	30	(15) 16	4	(10) 11	303	(285) 303	282	21	282	21

Note

Figures shown in this table indicate the cummulative through-puts represented by SD equivalent of CDU at its design capacity.
The figures with parenthesis indicate those represented by SD equivalent of AR HDS design capacity.

Figure 4.2

Attainable On-stream Factors : Case-2 Two Years Between Major Maintenance



(A) Maintenance
(B) Catalyst Replacement (15 days)

Period	Max. Operable Days W/O Tankage Limit		Loss in Operation Due to				Net Operable Days Attainable		Atmos. Residue Balance			
			Tankage Limit		Unsched. Shutdown				Supply		Uses	
	CDU	AR HDS	CDU	AR HDS	CDU	AR HDS	CDU	AR HDS	to AR HDS	to Tank	from CDU	from Tank
1-162th day	132	172	0	16	2	5	130	151	130	0	130	21
163-338th day	176	171	8	0	2	5	166	166	166	0	166	0
339-514th day	176	171	8	0	2	5	166	166	166	0	166	0
515-730th day	216	171	28	0	2	6	186	165	165	21	165	0
Whole Period	700	(645) 685	44	(15) 16	8	(20) 21	648	(610) 648	627	21	627	21

Note

Figures shown in this table indicate the cummulative through-puts represented by SD equivalent of CDU at its design capacity.

The figures with parenthesis indicate those represented by SD equivalent of AR HDS design capacity.

4.5 Product Loading

The bases required for determining the product loading facilities are set-up as follows:

Annual Operable Days of Sea Berth

It is said that large tanker's berthing and off-berthing operations and loading and unloading operations at sea berth are restricted under the following climatic and tidal conditions:

- Wind velocity over 10 m/second
- Wave height over 1.0 m
- Dense fog with visible distance of less than 1 km
- Tidal current of lateral direction over 0.5 knot

Based on the climatic data for Busher published by the Meteorological Office of Iran, number of days with wind velocity over 22 knot (11.3 m/second) and fogs are as follows:

Wind speed 22 knot or more	:	41 days
Fog	:	5 days

No information regarding waves is available. Then, it is assumed that the number of days not operable due to strong winds and high waves would be same as those wind velocity of 22 knot or more is observed taking into account the following:

a. It will be very rare case that the wind strong enough to restrict the tanker operation blows throughout the day.

b. High waves to restrict tanker operation will occur even when the wind velocity is rather low.

c. Based on a record of strong winds and high waves in the Setouchi sea area of Japan, the distributions of those to restrict tanker operation are as follows:

Strong wind alone	33 %
High wave alone	51 %
Both wind and wave	16 %

*) Based on observations of 12 times/day

Then, annual operable days of sea berth in Busher area is calculated as follows:

$$365 - (41 + 5) = 319 \text{ days}$$

Based on the interview to a tanker operating company, the tanker operating conditions in the Gulf is much better than those in the Tokyo Bay and almost same as those in the Setouchi sea area of Japan.
The number of operable days in these areas are thought to be:

Tokyo Bay	250 - 270 days/year
Setouchi	300 - 330 days/year

Therefore, the annual operable days of sea berth of 319 days as calculated above is considered to fall in reasonable range.

Operating Factor of Sea Berth

The maximum operating factor of berth is assumed to be 60 percent at which it is thought that operation is most effective.

Berth Occupancy Time

The berth occupancy time by tanker size is established as shown in Table 4.7 from results obtained in Japan.
The occupancy time shown in the above table includes allowance for tanker's waiting time to depart during daytime, although normal practice in the Gulf area is that tanker's arrival and departure are made during day and night.
In determining the required number of berths, a 20 percent allowance will be provided against those calculated based on the largest tankers to cover possible shipment by smaller size tankers.
It is considered that loading of various materials necessary for navigation including fuel, drinking water and foodstuffs be made during the loading time.

Shipping Schedule

A mixed cargo based shipping is adopted taking into account the increase in tankage requirement resulted from single product loading to large tankers.
The products are assumed to be loaded to a tanker with the following combinations:

Table 4.7

Berth Occupancy Time Classified by Tanker Size

Tanker Size (DWT)	Tanker Operation Time (Hrs)				Working Time at Sea Berth (Hrs)					Total Occupancy (Hrs)
	Arrival	Departure	Waiting for Depart.	Total	Preparation Work	Deballasting	Loading	Preparation for Depart.	Total	
200,000	2	1	1	4	5	8	24	6	43	47
130,000	2	1	5	8	5	6	18	4	33	41
90,000	2	1	1	4	5	5	12	2	24	28
50,000	1	1	1	3	5	5	7	2	19	22

<u>Note</u>

1. Time required for preparation work shown in the above table includes 3 hours for change-over of on-shore facilities and equipment on the tanker in the case of multi-grade loading.
2. It is assumed that tankers can arrive and depart during daytime.
3. Docked quarantine is assumed, and the time for it is included in the working time.

a. Gasoline and naphtha
b. Kerosene and gas oil
c. L/S and M/S fuel oils

The above products will be loaded to tankers via submarine pipelines, while bunker fuel oil and sulfur will be shipped by barges and general cargo boat respectively at the separately provided harbor due to their less fluidity and relatively small quantity to be shipped.

Simply from the technical point of view, the maximum size of full-loaded tankers navigable through the Malacca Straight is 250,000-280,000 DWT depending upon their design. However, the governments of Malaysia and Indonesia insist that the size of tankers be limited to 200,000 DWT. Therefore, the maximum size of tanker allowed for this study is considered to be 200,000 DWT.

In general, optimal size of tanker is determined based on the balance that freight costs decrementals, and tankage and other related costs incrementals resulted from the increased tanker size, and consequently, the larger the refining capacity, the larger the economical tanker size becomes.

In this study, however, the following tanker sizes are adopted for all refining capacities without detail study on such aspects:

White Oils	130,000 DWT
Black Oils	200,000 DWT

The larger size of tankers for white oil may be economical for 500,000 BPSD crude capacity.

4.6 Pollution Prevention

As for water pollution prevention,such facilities as will be needed to meet the following requirements for effluent water qualities are assumed to be provided:

PH	5.8 - 8.6
COD	60 ppm max.
Oil	5 ppm max.
SS	30 ppm max.

These figures are conforming to the minimum requirements for environments in Japan.

Facilities to handle ship's deballasting water is also assumed to be provided. However, there is a possibility to eliminate deballasting water handling facilities judging from the following facts:

a. Large tankers in service today, in general, are equipped with skimming devices to lessen oil content in ballast water during voyages to loading ports. Therefore, the ballast water held in vessels will be clean enough to discharges into sea directly, after such a long voyage as Japan to Iran.

b. The obligatory plan of equipping a separate ballast tank (SBT), as adopted by the February 1978 IMCO Tanker Safety and Ocean Pollution Control Pact Conference, will result in the reduction of loading terminals requirements in treating ship's deballasting water.

No special device for air pollution prevention, such as stack gas scrubbing, is considered in view of that the predominant wind direction and a distant location from the residential area would not cause any significant air pollution problem.

CHAPTER 5

PROJECT DESCRIPTION

CHAPTER 5

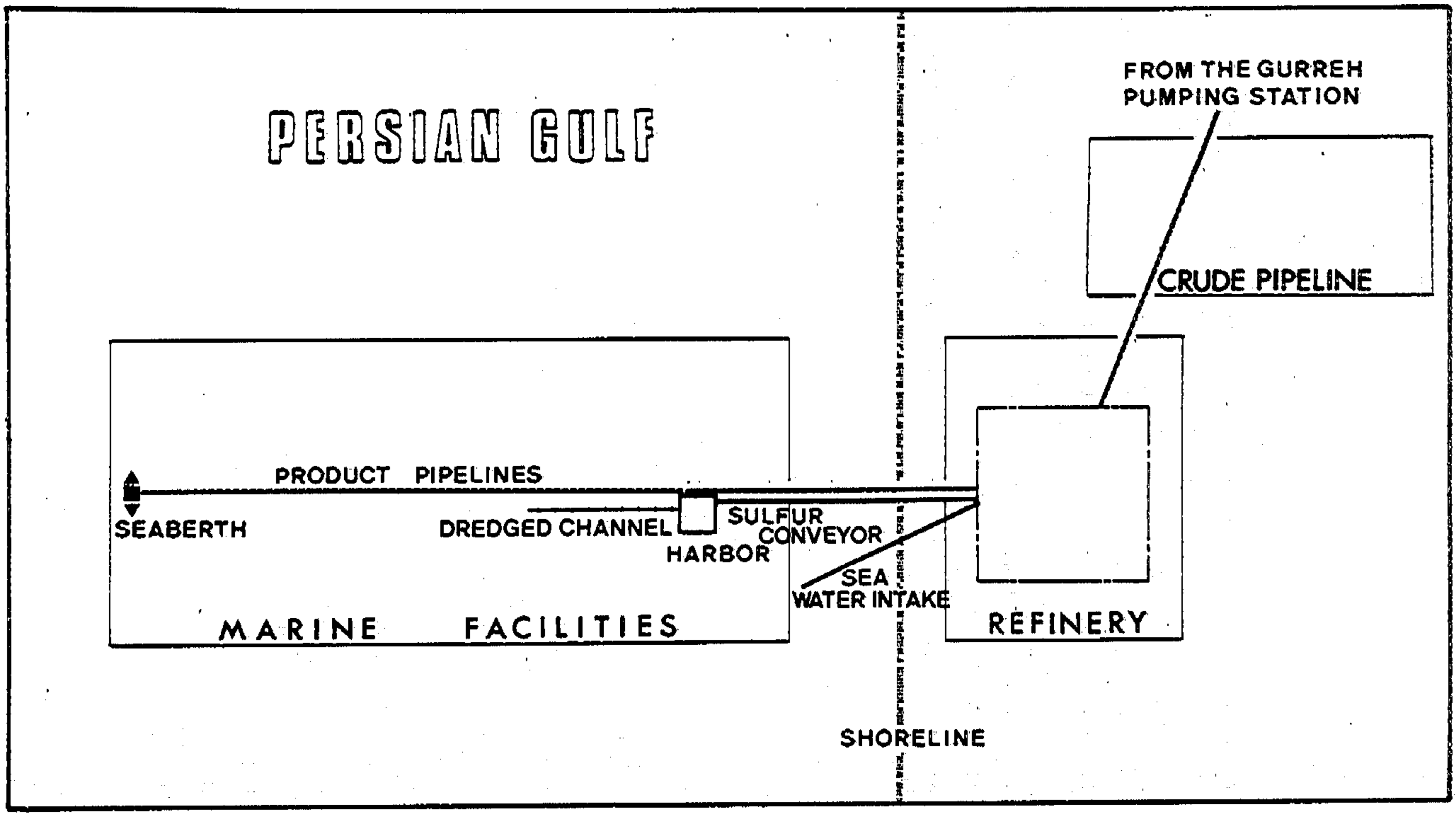
PROJECT DESCRIPTION

This chapter describes the plans on facilities of the subject export refinery project located at Muhammad Ameri which is designated as the base site among the selected four candidate sites.

The project is constituted by crude oil pipeline, refinery and marine facilities as shown on the frame of project in Figure 5.1.

Description is made for the project each having the refining capacity of 125,000 BPSD, 250,000 BPSD, and 500,000 BPSD with the refining configurations of hydroskimming and hydrocracking.

Effects on the project of locating the refinery at the alternative sites are discussed in Chapter 8, Site Selection.



☐ FRAME OF PROJECT   Fig 5-1

CRUDE OIL PIPELINES

5.1 Crude Oil Pipelines

The crude oils to be refined in the refinery are picked-up at the existing Gurreh pump station which is connected to the crude oil shipping terminal on Khark Island.

The crude oils, 50 percent of Iranian light crude and 50 percent of Iranian heavy crude, are transported through the segregated pipelines from the station to the refinery site at Muhammad Ameri, which is 165 Km far from the station. The pressure of the crude oils at the station is 900 psig (63 Kg/cm^2G) which enables to transport the crude oils to the refinery without further pumping.

The pipeline route map is presented in Figure 5.2. The pipelines begin at Gurreh pump station and first run toward south in parellel to the existing crude oil pipelines that reach Khark Island. At the northern part of Ganaveh, they change their direction to the south east and then go along the existing communication cables and reach Chughadak after about 125 Km. From Chughadak, they follow to the road running straight toward south and reach Muhammad Ameri.

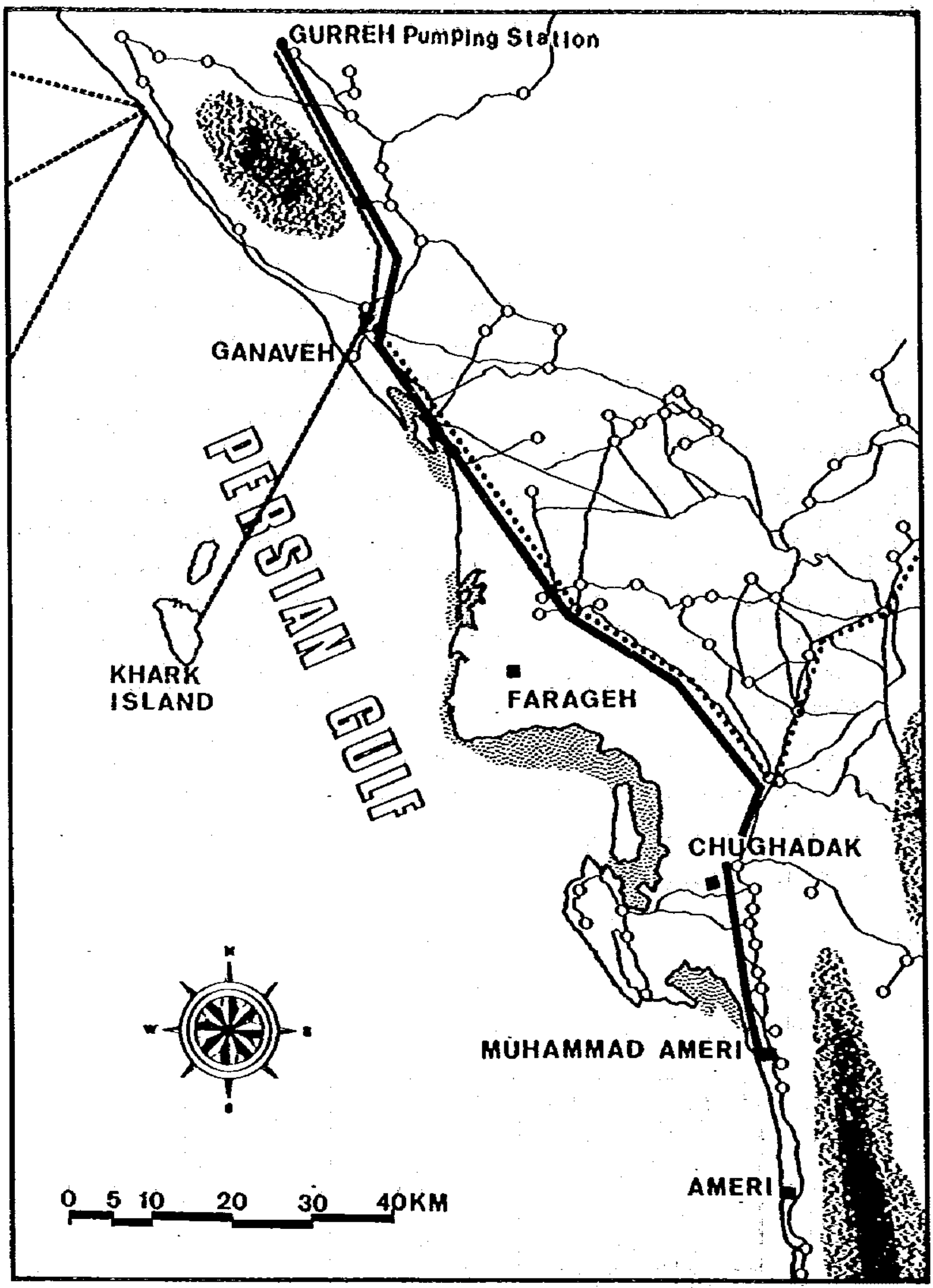
The pipelines are buried under ground for the entire distance of 165 Km including intersections with rivers, wadis, and main roads.

The piping size for each flow rate which corresponds with the three cases of refining capacities is given as follows:

Table 5.1

Pipeline Size

Refining Capacity (BPSD)	Piping Size (Inches)	Number of Pipes
125,000	16	2
250,000	20	2
500,000	26	2



LEGEND

- EXISTING PIPELINE
- NEW PIPELINE
- EXISTING TELEGRAPH
- ROAD
- CANDIDATE SITE

CRUDE OIL PIPLINE ROUTE

Fig 6.2

REFINERY

CASE 1 : HYDROSKIMMING TYPE

5.2 Case 1: Hydroskimming Type Refinery

This section outlines the planned hydroskimming type refinery with three different capacities, namely, 125,000 BPSD, 250,000 BPSD, and 500,000 BPSD.

5.2.1 Process Units

As shown in the refinery flow scheme presented in Figure 5.3, this case represents a refinery with a combination of the skimming processes (crude distillation) and the hydrogen-treating processes (desulfurization). Thus the refinery produces the desired products in such a slate as crude natural yield allows without cracking.

The percentage yield of each salable products from this refinery is shown below:

Table 5.2

Product Yields of Case 1 Refinery

Products	Yields, Vol% on Crude
Gasoline	10.0
Naphtha	9.9
Kerosene	14.1
Gas Oil	21.1
Low Sulfur Fuel Oil	28.2
Medium Sulfur Fuel Oil	7.0
Bunker Fuel Oil	3.0
Total	93.3

Further, production volumes of products for the three refining capacities are shown in Table 5.3 and a comparison between product specification and estimated actual properties of products obtained is shown in Table 5.4.

Refinery Scheme

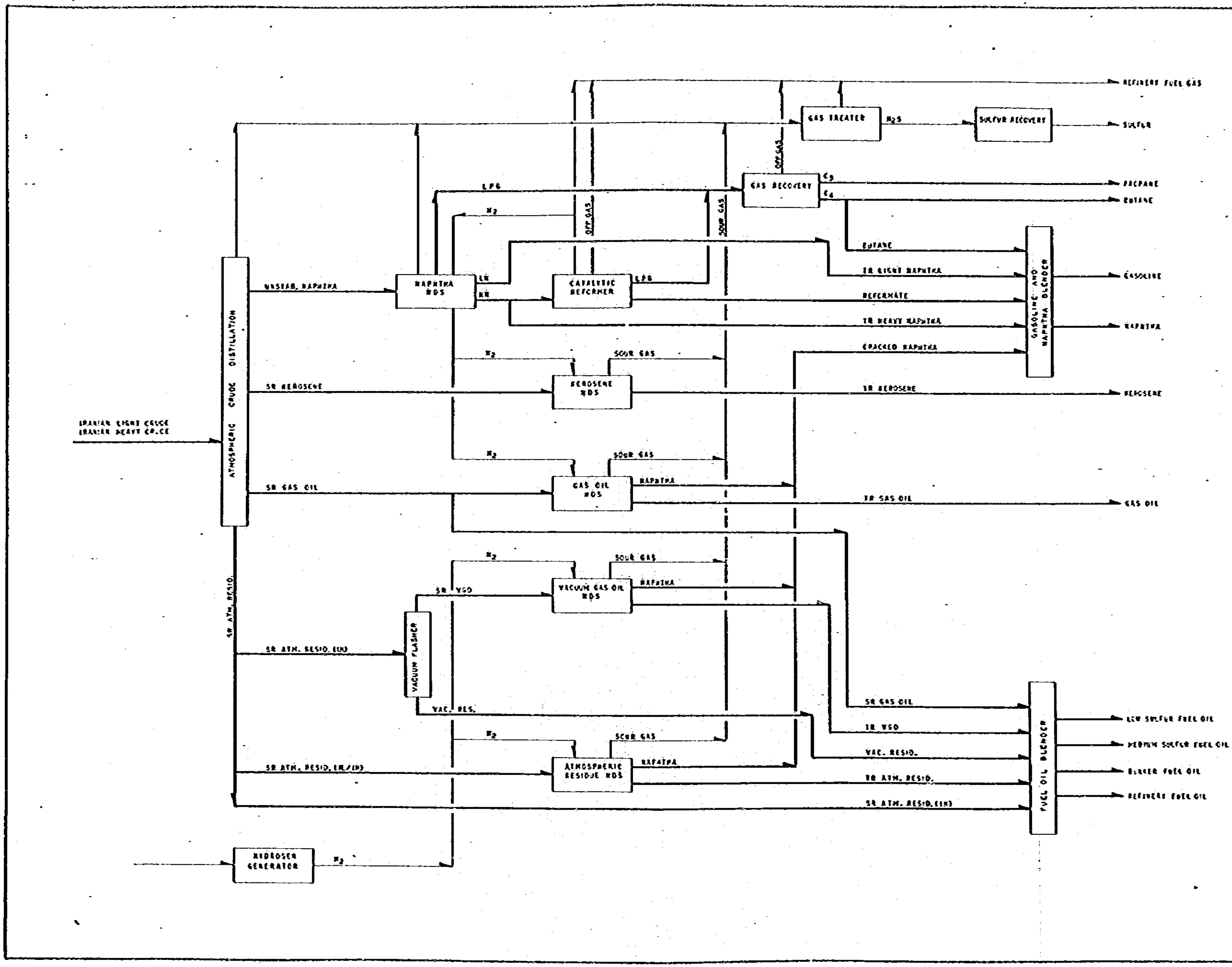
The Iranian light and Iranian heavy crude oils are fed to the respective atmospheric crude distillation units, and distilled at the following separation temperatures:

Table 5.3

Summary of Crude and Products

Case 1 Hydroskimming

	125,000 BPSD	250,000 BPSD	500,000 BPSD
	BPCD	BPCD	BPCD
1.Crude Oil			
Iranian Light Crude	53,125	106,250	212,500
Iranian Heavy Crude	53,125	106,250	212,500
Total	106,250	212,500	425,000
2.Products			
(1) Salable Products			
Gasoline	10,625	21,250	42,500
Naphtha	10,470	20,940	41,880
Kerosene	14,980	29,960	59,920
Gas Oil	22,405	44,810	89,620
L/S Fuel Oil (0.1%S)	29,965	59,930	119,860
M/S Fuel Oil (1.5%S)	7,490	14,980	29,960
Bunker Fuel Oil	3,190	6,380	1,2760
Total	99,125	198,250	396,500
Sulfur	150 TPCD	300 TPCD	600 TPCD
(2) Refinery Use			
Off Gas	980 EFO	1,960 EFO	3,920 EFO
Propane	890	1,780	3,560
Butane	960	1,920	3,840
Refinery Fuel Oil	4,905	9,810	19,620



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BLOCK FLOW DIAGRAM
CASE-1: HYDROSKIMMING
Figure 5.3

Table 5.4

Product Qualities Summary

Case 1 Hydroskimming

Products	Properties	Specification	Estimated Actual Value
Gasoline	Specific Gravity (15/4°C)	-	0.746
	RON, F-1 Clear	Min. 90	90
	RVP @37.8°C ,Kg/cm^2	0.45 - 0.63	0.63
	ASTM Distillation (D-86), °C		
	10%	Max. 65	44
	50%	Max. 120	76
	90%	Max. 180	145
	97%	Max. 205	166
Naphtha	Specific Gravity (15/4°C)	-	0.725
	RVP @37.8°C ,Kg/cm^2	Max. 0.63	0.63
	Sulfur Content ,wt.%	Max. 0.01	0.01
	EP ,°C	Max. 200	190
Kerosene	Specific Gravity (15/4°C)	-	0.801
	Flash Point (Tag) ,°C	Min. 40	45
	Smoke Point ,mm	Min. 24	24
	Sulfur Content ,wt.%	Max. 0.005	0.005
	ASTM Distillation (D-86), °C		
	IBP	Min. 150	161
	95%	Max. 235	229
Gas Oil	Specific Gravity (15/4°C)	-	0.855
	Flash Point (P-M) ,°C	Min. 50	110
	Pour Point ,°C	Max. -7.5	-9.0
	Cetane No.	Min. 50	55
	Sulfur Content ,wt.%	Max. 0.1	0.05
	ASTM Distillation (D-86), °C		
	90%	Max. 350	334
L/S Fuel Oil	Specific Gravity (15/4°C)	-	0.918
	Flash Point ,°C	Min. 60	60
	Sulfur Content ,wt.%	Max. 0.1	0.1
	Viscosity @50°C ,cSt	Max. 150	40
M/S Fuel Oil	Specific Gravity (15/4°C)	-	0.942
	Flash Point ,°C	Min. 60	60
	Sulfur Content ,wt.%	Max. 1.5	1.5
	Viscosity @50°C ,cSt	Max. 150	150
Bunker Fuel Oil	Specific Gravity (15/4°C)	-	0.951
	Sulfur Content ,wt.%	Max. 3.5	2.4
	C.C.R. ,wt.%	Max. 12	9.2
	Viscosity @50°C ,cSt	Max. 250	250

Note: The estimated value of aromatics content in gasoline is 38 vol.%.

Naphtha	Less than 154°C
Kerosene	154 - 235°C
Gas Oil	235 - 371°C
Residue	Over 371°C

The overhead distillate from the atmospheric crude distillation units is treated in the naphtha hydrodesulfurizer and separated into LPG, light naphtha and heavy naphtha.

The separated light naphtha is run down to storage tanks and is blended into gasoline and product naphtha.
A part of the heavy naphtha is processed in the catalytic reformer into reformate with octane number of RON 98, while the remaining heavy naphtha is run down to storage tanks and blended into the product naphtha together with the light naphtha and cracked naphtha.

The LPG fraction from the naphtha hydrodesulfurizer and catalytic reformer is fed to the gas recovery unit where propane and butane are separately recovered.
Of the recovered LPGs, all the propane is consumed as refinery fuel, and butane is partly blended into gasoline and product naphtha within the vapor pressure specifications limit. The remaining butane is entirely consumed as a fuel in the refinery, while no shipment as product.

The kerosene fraction from the atmospheric crude distillation units is directed to product kerosene tanks after being treated in the kerosene hydrodesulfurizer.

Most of the gas oil fraction is sent to product gas oil pool after desulfurizing, while a small portion of it is used without further treatment as blending stock for bunker fuel oil.

The atmospheric residue from Iranian light crude oil is entirely hydrodesulfurized into fuel oil with a sulfur content of 0.1 wt.%. While, the residue from Iranian heavy crude is routed to the following:

- Atmospheric residue hydrodesulfurizer together with Iranian light residue.
- Vacuum gas oil hydrodesulfurizer after vacuum flashing.
- Fuel oil blending.

The sour gas streams from distillation and hydrodesulfurization units are amine washed for H_2S removal and sent to the refinery fuel system, while the recovered H_2S is fed to the sulfur recovery unit.

The hydrogen necessary for the naphtha, kerosene and gas oil hydrodesulfurizers is supplied from the catalytic reformer, while from the hydrogen generator for the vacuum gas oil and atmospheric residue hydrodesulfurizers. The feedstock of hydrogen generator is refinery off-gas.

Installed Capacity

The capacity and number of units of the individual process units are defined for each refinery scale, i.e., 125,000, 250,000 and 500,000 BPSD taking into account the operation and maintenance schedule. The number of refining trains for each refinery scale is determined to be one for 125,000 and 250,000 BPSD and two for 500,000 BPSD.

Despite the above, the gas treating and sulfur recovery units are defined to have two independent units per refining train to enable continuous service when one group is in maintenance, while the other group is in operation.

In defining the installed capacity of each process units, the following bases are used:

- An on-stream factor of 80 percent for the atmospheric residue hydrodesulfurizers.
- An on-stream factor of 85 percent for the other units.
- To cover peak loads of hydrogen consumed and sour gas generated for hydrogen generator, gas treater and sulfur recovery.

The installed capacity of the process units is summarized in Table 5.5 for each refining scale.

5.2.2 Utilities System

One of the major factors essential to the successful operation of a grassroots refinery is the reliable supply of the necessary utilities.
Based on the prevailing local conditions of Muhammad Ameri, the integrated system and facilities for supplying these services are investigated and defined.
Particular attentions are given to the reliability of the system, and the stable supply of the utilities on a self-supporting basis.

Table 5.5

Installed Capacities of Process Units

Case 1 Hydroskimming

Process Unit	Unit	125,000 BPSD		250,000 BPSD		500,000 BPSD	
		Capacity	No.s	Capacity	No.s	Capacity	No.s
Atmospheric Crude Distillation	BPSD	125,000 *)	1	125,000	2	125,000	4
Vacuum Flasher	BPSD	14,000	1	27,900	1	27,900	2
Gas Recovery	BPSD	3,800	1	7,500	1	7,500	2
Naphtha Hydrodesulfurizer	BPSD	26,500	1	52,900	1	52,900	2
Catalytic Reformer	BPSD	9,700	1	19,300	1	19,300	2
Kerosene Hydrodesulfurizer	BPSD	17,700	1	35,300	1	35,300	2
Gas Oil Hydrodesulfurizer	BPSD	26,900	1	53,800	1	53,800	2
Vacuum Gas Oil Hydrodesulfurizer	BPSD	7,200	1	14,300	1	14,300	2
Vacuum Gas Oil Hydrocracker	BPSD	-	-	-	-	-	-
Atmospheric Residue Hydrodesulfurizer	BPSD	34,900	1	69,800	1	69,800	2
Visbreaker	BPSD	-	-	-	-	-	-
Hydrogen Generator	$10^6 Nm^3/SD$	0.83	1	1.66	1	1.66	2
Gas Treater	TPSD (as H_2S)	100	2	200	2	200	4
Sulfur Recovery	TPSD (as S)	90	2	180	2	180	4
Foul Water Stripper	TPSD	990	1	1,980	1	1,980	2

*) Dual Flasher Type

Overall Supply System

The overall system diagram for steam, power, and water is presented in Figure 5.4.

The refinery generates and consumes steam at three pressure levels as follows:

- High pressure steam - 43 Kg/cm^{2}G, 400°C
- Medium pressure steam - 15 Kg/cm^{2}G, 270°C
- Low pressure steam - 3.5 Kg/cm^{2}G, Saturate

High pressure steam generated in the oil fired boilers is consumed in steam turbines for power generation and as motive steam for the major gas compressors in the catalytic reformer, vacuum gas oil hydrodesulfurizer, and atmospheric residue hydrodesulfurizer as well as for driving refinery air compressors.

The medium pressure steam is generated from waste heat boilers equipped in the catalytic reformer and hydrogen generator and also is extracted from the power generation turbines.
It is consumed as motive steam for small drivers and as heating and atomizing steams.
Low pressure steam is generated from waste heat boilers and exhausted from steam turbines, and is consumed as deaeration steam for boiler feed water and also as heating and stripping steam for various equipment.

The extracting-condensing turbines are adopted for electric power generation. The balance of medium pressure requirements can be adequately supplied by controlling the rate of extraction, while the supply of power demand can be kept easily by controlling the rate of steam to be condensed. Steam condensate is collected where practicable, and recirculated after being filtered.

Two kinds of cooling water system are provided, one is the sea water cooling for the services where applicable to the maximum extent and the other is the fresh water cooling system.
Both systems are designed to save the make-up waters by adopting a recurculating system through the individual cooling towers.

The refinery uses the three types of fuels as follows:

- Refinery off gas
- LPG
- Heavy fuel oil

Gases from various process units are collected and sweetened in the amine gas treating unit and then sent to the mixing drum. LPG from storage is also sent to the mixing drum through the LPG vaporizer to sustain the mixed fuel gas at a predetermined heating value. While, home fuel oil normally used is a vacuum residue of Iranian heavy crude. The oil is drawn from the storage tank and pumped to boilers and process furnaces after being heated up to 160°C. Provision is made for the system to recirculated the fuel oil to attain stable supply.

The air compressors to supply the instrument and plant air are provided as required. Furthermore, inert gas generators of air separation type are provided to supply the entire refinery's demand.

<u>Utilities Balance</u>

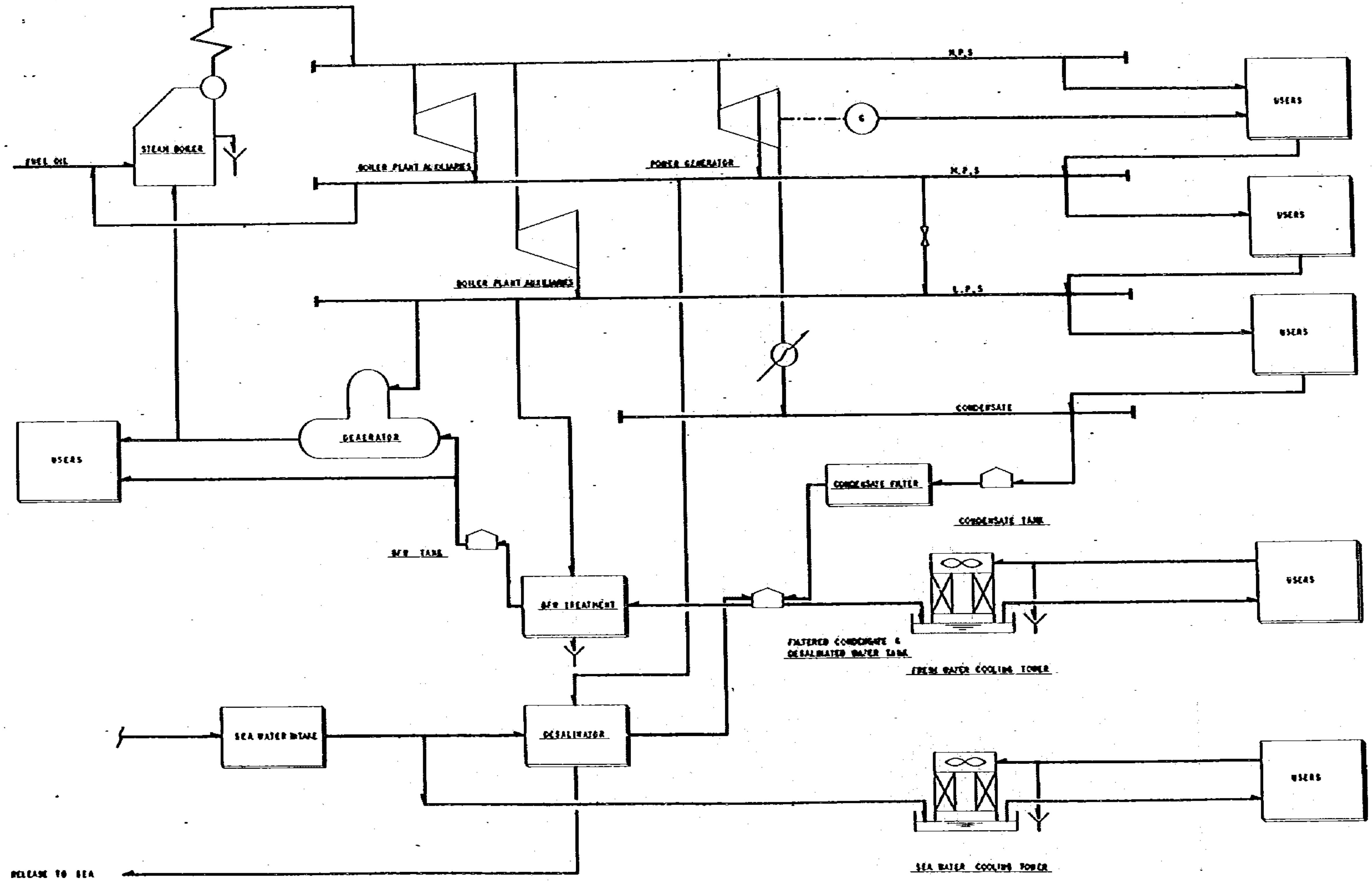
Table 5.6 shows the utilities balance in the case of a refinery capacity of 250,000 BPSD on a calendar day basis (yearly average). This table indicates the consumption and generation rates of utilities such as electric power, fuel, three perssure level steams, sea water, fresh water, steam condensate, pure water, boiler feed water for each units in the refinery.
Positive values indicated in the table represent consumption, while negative values for generation. Utilities requirements for each refinery capacity are summarized in Table 5.7.

<u>Installed Capacity</u>

The capacities of the individual utility facilities are defined on an operating day basis taking into account the peak loads (normal maximum).
For the major facilities shown below, one unit is provided for standby service:

- Steam boiler
- Electric power generator
- Sea water desalinator
- Polisher
- Cooling water circulation pump
- Air compressor

The installation summary of the utilities system for each refinery capacity is presented in Table 5.8.



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STEAM, POWER AND WATER SYSTEM DIAGRAM

Figure 6.4

Table 5.6 Utility Balance (Case 1 Hydroskimming 250,000 BPSD)

	Elec. Power	Fuel	Steam			Water		Steam Cond.	B.F.W.	
			H.P.	M.P.	L.P.	Sea	Fresh		Cold	Hot
	KW	10^6 Kcal/CD	Ton/CD	Ton/CD	Ton/CD	10^3 Ton/CD	Ton/CD	Ton/CD	Ton/CD	Ton/CD
Atmos. Crude Distillation	4,480	2,801		970	327	40.8	1,224	-458		
Vacuum Flasher	530	504		168	- 19	13.5	189			81
Gas Recovery	90				147	20.0	153	-146		
Naphtha HDS	1,720	1,373		43		32.6	605			156
Cat. Reformer	270	1,178	377	-319	-377	30.6	113			360
Kerosene HDS	1,400	576		72		40.4	391			125
Gas Oil HDS	3,120	1,063		120		67.2	667			202
VGO HDS	980	211	122	41	- 62	4.7	468			67
Atmos. Residue HDS	12,790	1,272	867	- 94	-737	109.9	3,485	-274		979
Gas Treating	330			74	1,193	18.9	46	-1,267		9
Sulfur Recovery	740	264			-749	2.4	48	-149		925
Hydrogen Plant	1,210	1,932		-192	173	10.4	905	- 38	1,891	
Foul Water Stripper	180				483	16.0		-461		
On-Site Total	27,840	11,174	1,366	883	379	407.4	8,294	-2,793	1,891	2,904
Off-Site Total	3,000		216	480	672	2.6	552	-120		
Steam Generator		7,826	-9,125	-903	-773					11,196
Deaerator					2,069				12,031	-14,100
Power Generator	-33,810		5,856	-2,123		187.0		-3,734		
BFW Treatment	290				53			14,024	-13,922	
Desalinator	570			950				-8,482		
Sea Water Intake	1,140									
SW Cooling Tower	960		1,663		-1,663	-597.0				
FW Cooling Tower	10		24		-24		-8,846	1,105		
Utility Total	-30,840	7,826	-1,582	-2,076	-338	-410.0	-8,846	2,913	-1,891	-2,904
Refinery Grand Total	0	19,000	0	-713	713	0.0	0	0	0	0

Notes: 1) Sea water Intake: 156,000 Ton/CD
2) Positive figures mean consumption, while negative figures for production.

Table 5.7

Summary of Utility Requirements

Case 1 Hydroskimming

Requirement	Unit	125,000 BPSD	250,000 BPSD	500,000 BPSD
Electric Power	KW	16,900	33,800	67,600
Total Fuel	10^6 Kcal/CD	9,500	19,000	38,000
Steam	TON/CD	5,500	10,900	21,800
Cooling Sea Water	TON/CD	298,500	597,000	1,194,000
Cooling Fresh Water	TON/CD	4,400	8,800	17,600
Net Boiler Feed Water	TON/CD	3,800	7,500	15,000
Net Sea Water Intake	TON/CD	78,000	156,000	312,000

Table 5.8

Installation Summary: Utility Facilities

Case 1 Hydroskimming

Facility	125,000 BPSD		250,000 BPSD		500,000 BPSD		Remarks
	Capacity	No.s	Capacity	No.s	Capacity	No.s	
1. Steam Generator	170 Ton/Hr	3	310 Ton/Hr	3	400 Ton/Hr	4	44 Kg/cm^{2}G, 410 $^{\circ}$C One unit for stand-by
2. Power Generator	14,000 KW	3	16,000 KW	4	19,000 KW	6	Extracting-condensing One unit for stand-by
3. Desalinator	2,400 Ton/day	3	4,700 Ton/day	3	9,100 Ton/day	3	One unit for stand-by
4. BFW Treatment							
- Condensate Filter	130 Ton/Hr	2	240 Ton/Hr	2	310 Ton/Hr	3	
- Mixed Bed Polisher	220 Ton/Hr	3	410 Ton/Hr	3	540 Ton/Hr	4	One unit for stand-by
- Water Tanks							
a) Condensate Tank	1,500 KL	2	2,500 KL	2	5,000 KL	2	
b) Filtered Cond. & Desal.W.Tank	10,000 KL	2	20,000 KL	2	40,000 KL	2	
c) BFW Tank	2,500 KL	2	5,000 KL	2	10,000 KL	2	
5. Cooling Water System							
- Sea Water Cooling Tower	18,000 M^3/Hr	1	17,000 M^3/Hr	2	17,000 M^3/Hr	4	
- Fresh Water Cooling Tower	300 M^3/Hr	1	550 M^3/Hr	1	1,000 M^3/Hr	1	
6. Sea Water Intake							
- Pumps	2,500 M^3/Hr	3	5,000 M^3/Hr	3	6,500 M^3/Hr	4	One pump for stand-by
- Piping	32 inch (5,000 M^3/Hr)	1	42 inch (10,000 M^3/Hr)	1	54 inch (20,000 M^3/Hr)	1	
7. Air System	1,500 Nm^3/Hr	3	2,000 Nm^3/Hr	3	2,000 Nm^3/Hr	5	
8. Inert Gas System	250 Nm^3/Hr	2	500 Nm^3/Hr	2	1,000 Nm^3/Hr	2	
9. Fuel Oil Pump	40 Ton/Hr	3	75 Ton/Hr	3	145 Ton/Hr	3	One pump for stand-by
10. Fuel Gas System							
11. Potable Water System							
- Chlorinator	10 Ton/Hr	1	10 Ton/Hr	1	20 Ton/Hr	1	
- Tank	1,000 KL	1	1,000 KL	1	1,000 KL	2	

5.2.3 Offsite Facilities

Tankage and Blending Facilities

The planned oil handling system of the refinery is illustrated in the tank flow diagram, Figure 5.5.

Both Iranian light and Iranian heavy crude oils are delivered by the two crude oil pipelines and stored in separate tanks which are capable of accommodating full plant requirements for seven days' normal operation.

The following process intermediate tankage is provided to enable to continue its operation when the other units are shut down for maintenance or catalyst regeneration and replacement:

Stream	Process Unit Charged	Storage Days
SR Kerosene	HDS	18
SR Gas Oil	HDS	18
SR VGO	HDS	7
Atm. Residue (IL/IH)	HDS	18

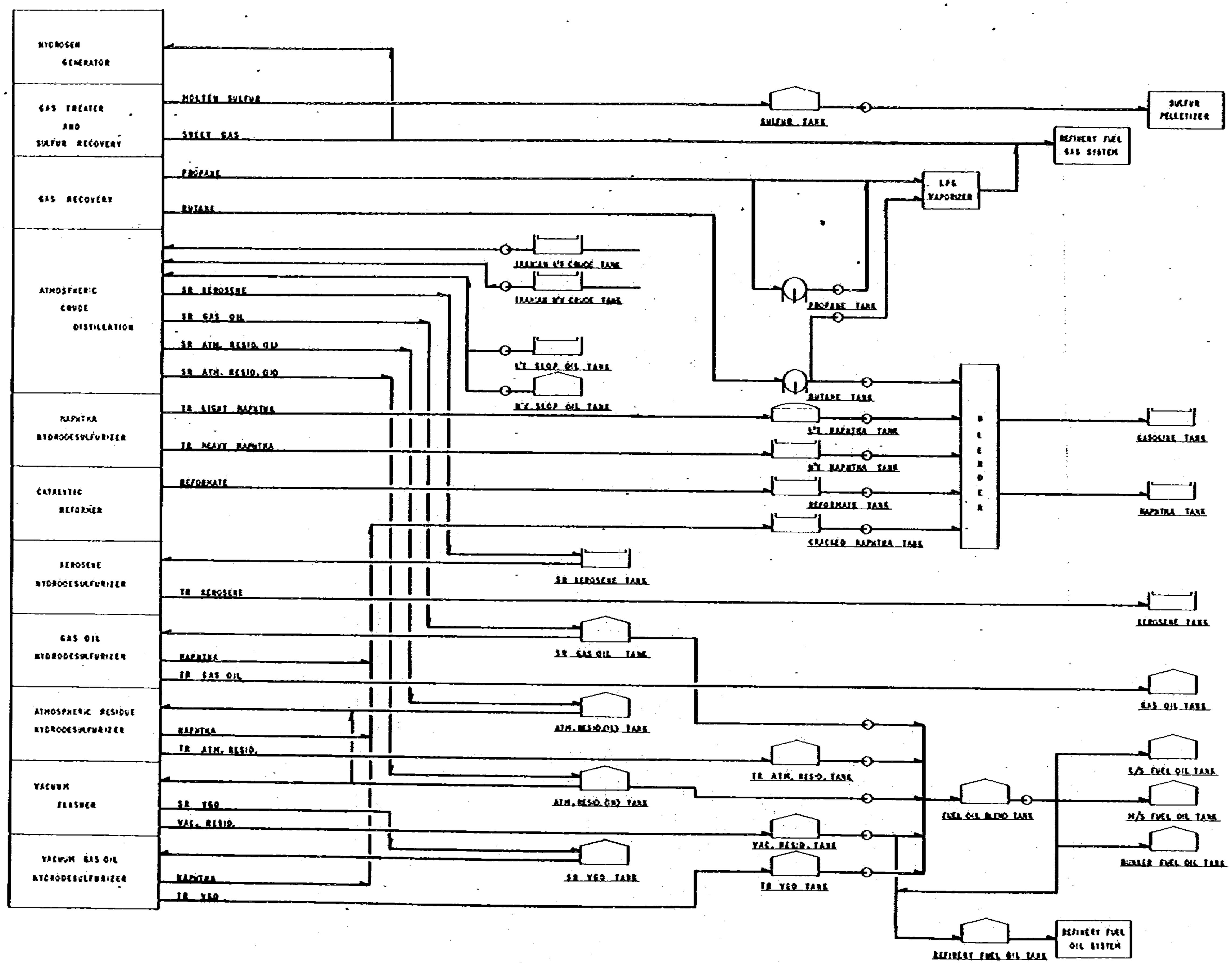
The component oils before blending and finished products leaving the process units run into large semi-product and product tanks respectively. Total product tankage capacities including these for semi-products before blending are defined to be for 30 days minimum and, in principle, 15 days' capacity for semi-product.

Furthermore, product tankage is defined to have a capacity not less than 1.5 times of one shipment by the maximum size product carrier. The tankage for other services is defined based on the following:

- Bunker fuel oil 15 days
- Refinery fuel oil 6 days
- Refinery propane 5 days
- Liquid sulfur 3 days

The planned tankage for each case is summarized in Table 5.9. The tanks in the above table include a 15 percent safety factor.

Component oils stored in individual semi-product tanks are blended into the desired products with a schedule as shown in Table 5.10. Blending of gasoline and naphtha is performed by the commonly installed in-line blender. Based on each blending plan in the table, the required components are pumped simultaneously at controlled rates into a blending header.



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TANK FLOW DIAGRAM
CASE - 1 : HYDROSKIMMING
Figure 5.5

Table 5.9 Tankage Summary: Case 1 Hydroskimming

Service	125,000 BPSD		250,000 BPSD		500,000 BPSD		Remarks
	No.s	Capacity,KL	No.s	Capacity,KL	No.s	Capacity,KL	
1. Crude Oil Tanks							
Iranian Light Crude	2	37,500	2	75,000	3	100,000	FRT
Iranian Heavy Crude	2	37,500	2	75,000	3	100,000	FRT
2. Intermediate Tanks							
Straight Run Kerosene 1)	1	60,000	2	60,000	2	60,000	FRT
Straight Run Gas Oil 1)	2	50,000	3	60,000	3	60,000	CRT
Atmospheric Residue (IL)	2	40,000	3	60,000	6	60,000	CRT
Atmospheric Residue (IH) 2)	2	30,000	2	50,000	4	50,000	CRT
Straight Run Vacuum Gas Oil	1	10,000	1	20,000	2	20,000	CRT
3. Semi-Product Tanks							
Propane	2	500	2	1,000	4	1,000	SPH
Butane	3	2,500	5	3,000	10	3,000	SPH
Light Naphtha	2	10,000	2	15,000	4	15,000	DRT
Heavy Naphtha	2	15,000	2	25,000	4	25,000	FRT
Reformate	2	10,000	2	20,000	4	20,000	FRT
Cracked Naphtha	1	5,000	1	10,000	2	10,000	FRT
Treated Atmospheric Residue	2	50,000	4	50,000	8	50,000	CRT
Treated Vacuum Gas Oil	2	10,000	2	20,000	4	20,000	CRT
Vacuum Residue	2	10,000	2	20,000	4	20,000	CRT
4. Product Tanks							
Gasoline	3	50,000	3	50,000	3	50,000	FRT
Naphtha	3	50,000	3	50,000	3	50,000	FRT
Kerosene	2	50,000	4	50,000	8	50,000	FRT
Gas Oil	3	50,000	5	60,000	10	60,000	CRT
Low Sulfur Fuel Oil	5	60,000	5	60,000	8	50,000	CRT
Medium Sulfur Fuel Oil	2	40,000	2	40,000	2	50,000	CRT
Bunker Fuel Oil	1	15,000	1	15,000	1	15,000	CRT
5. Other Service Tanks							
Refinery Fuel Oil	2	4,000	2	7,000	4	7,000	CRT
Fuel Oil Blending	2	5,000	2	10,000	4	10,000	CRT
Light Slop Oil	1	10,000	1	10,000	2	10,000	FRT
Heavy Slop Oil	1	10,000	1	10,000	2	10,000	CRT
Molten Sulfur	1	500	1	1,000	2	1,000	CRT
Grand Total	56	1,667,000	67	2,577,000	116	4,279,000	

Notes: 1) Interchangeable with Product Tanks
2) Common for Intermediate and Semi-Product Tanks

Table 5.10

Products Blending Table

Case 1 Hydroskimming 250,000 BPSD

Blending Component	BPCD	Refinery Fuel Gas	Gasoline	Naphtha	Kerosene	Gas Oil	L/S Fuel Oil	M/S Fuel Oil	Bunker Fuel Oil	Refinery Fuel Oil
Off Gas	1,958 (EFO)	1,958 (EFO)								
Propane	1,777	1,777								
Butane	4,080	1,923	726	1,431						
Treated Light Naphtha	9,987		7,486	2,501						
Treated Heavy Naphtha	14,241			14,241						
Reformate	13,038		13,038							
Craked Naphtha	2,769			2,769						
Treated Kerosene	29,963				29,963					
Straight Run Gas Oil	1,128								1,128	
Treated Gas Oil	44,814					44,814				
Straight Run Atmos.Residue(IH)	10,900							5,653	5,247	
Treated Atmos. Residue	55,443						55,443			
Treated Vacuum Gas Oil	12,023						4,475	7,548		
Straight Run Vacuum Residue	11,589							1,779		9,810
Total	213,710	5,658	21,250	20,942	29,963	44,814	59,918	14,980	6,375	9,810

Blending of fuel oils is carried out by in-line blending followed by blending tanks were further adjustments are performed and then transferred to product tanks.

Products Shipping System

The products are pumped from product tanks to a marine loading terminal by means of pipelines over a total distance of 19 Km covering 4 Km of on-shore causeway and 15 Km of submarine from the end of the causeway as shown in Figure 5.6.

Tanker loading time at the sea berth is assumed to be 18 hours for a ship of 130,000 DWT for white oils and 24 hours for a ship of 200,000 DWT for black oils.

Three pipelines are provided for white oil loadings, i.e., one line for gasoline and naphtha, one line for kerosene and gas oil and one line for common use.

One common pipeline is provided for low sulfur fuel oil and medium sulfur fuel oil shipping.

This line is scheduled to be flushed with gas oil after loading operation to prevent set up of heavy oils in the line.

One pipeline for supplying potable water to tankers and one pipeline to discharge of deballasting water from tankers are provided additionally.

While, the ship's bunker fuel oil is transported from the refinery to the harbor through on-shore pipeline and then delivered to tankers by means of barges.

Table 5.11 represents the planned capacity of the shipping pumps and the size of the pipelines.

Solid Sulfur Handling System

The molten sulfur stored in the high temperature sulfur tank is pelletized for shipment. The pelletized sulfur is temporarily stored outdoors in piled form and then transported by means of the conveyor belt along the causeway to the sulfur shipping wharf located at the end of the causeway and 4 Km far from the refinery.

Based on the operation schedule that operating hours of the pelletizer are eight (8) hours per day and the maximum tonnage of a sulfur carrier is 10,000 DWT, this system is defined to be made up as shown in Table 5.12.

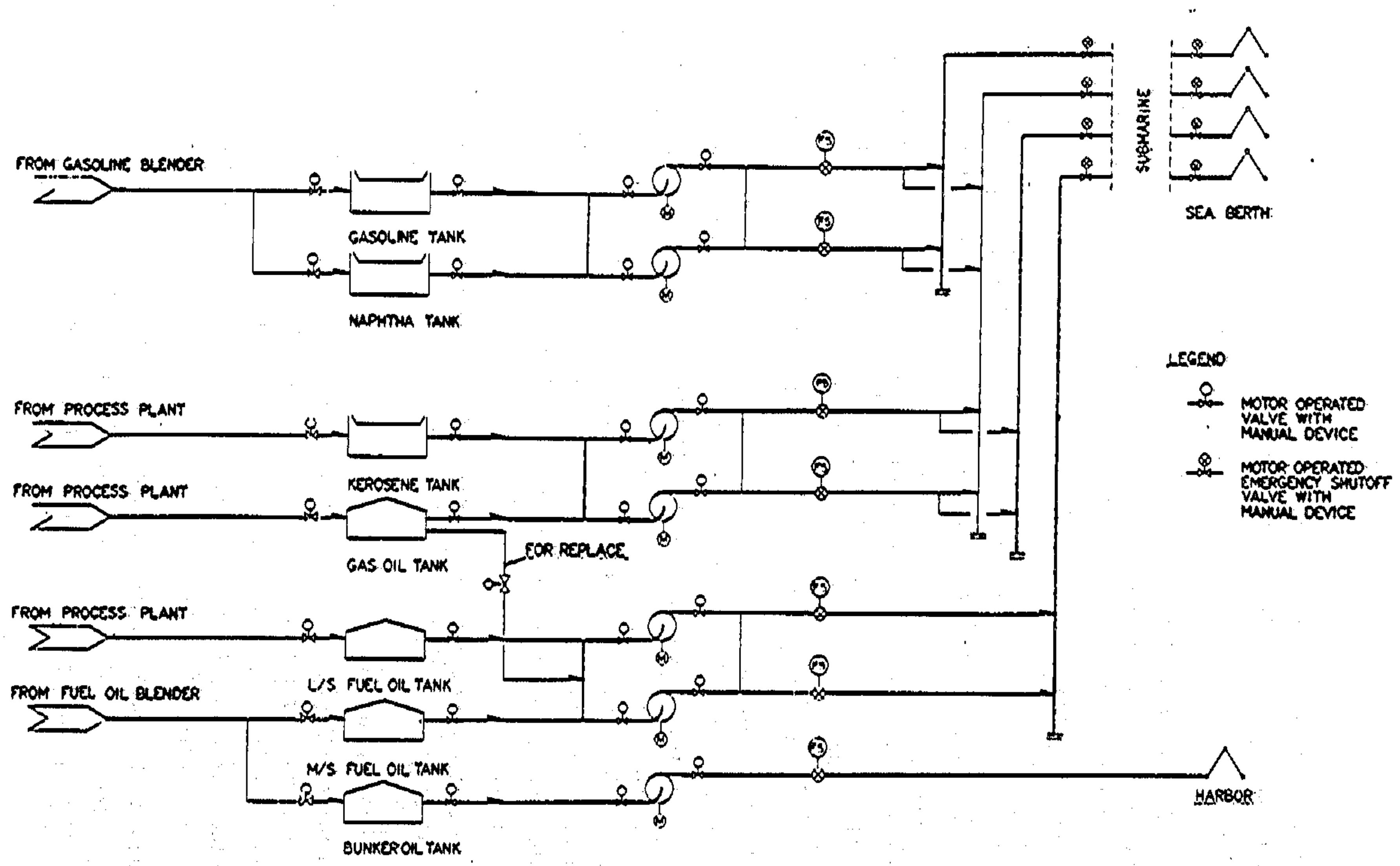


Figure 5.6

SIMPLIFIED FLOW DIAGRAM
FOR
PRODUCT SHIPPING FACILITY

Table 5.11

Installed Capacity of Product Shipping System

Service	Shipping Pumps	Pipelines
Gasoline Naphtha Kerosene Gas Oil	5,000 m^3/H x 4	32 inches x 3
L/S Fuel Oil M/S Fuel Oil	5,000 m^3/H x 2	42 inches x 1
Bunker Fuel Oil	1,000 m^3/H x 2	16 inches x 1
Potable Water	50 m^3/H x 2	4 inches x 1
Ballast Water	-	22 inches x 1

Table 5.12

Installed Capacity of Solid Sulfur Handling System

Case :	125,000 BPSD	250,000 BPSD	500,000 BPSD
Sulfur Pelletizer	20 Ton/H	40 Ton/H	80 Ton/H
Storage Yard	5,500 m^2	5,500 m^2	5,500 m^2
Conveyor Belt	500 Ton/H	500 Ton/H	500 Ton/H

Catalyst Loading and Unloading System

The atmospheric residue hydrodesulfurizer requires catalyst replacement at every six months intervals.

On this occasion, spent and deteriorated catalyst is withdrawn from the reactor and hauled away by truck after packing into drums. On the other hand, fresh catalyst is lifted to the level of the charging ports with bucket elevators and loaded into the reactor by means of conveyor belt.

The volume of catalyst replaced and the time required are estimated for a 69,800 BPSD of the atmospheric residue hydrodesulfurization unit (reactor 2 trains).

- Catalyst replaced: Annually 450 Ton x 2 Times
- Required time : 15 days per time

Fire-fighting System

A fire water system to store, pump, and distribute sea water throughout the plant for fire protection and fire-fighting is provided. Water for the fire service is drawn from the sea water intake pit and pumped up to the water distribution header.

Three 410 m^3/H fire water pumps including one spare pump (one is electric motor driven and two are diesel driven) are provided to distribute fire water to hydrants and turrets spaced strategically to protect all areas of the plant. The hydraulic pressure at each fire hydrant is maintained at 7 Kg/cm^2G.

For the high pressure gas facilities in the LPG spherical tank area, water sprays are provided.

The refinery has a self-defence fire-fighting system centralized in the fire station where the following vehicles are provided:

- Foam fire engines
- Powder fire engines
- Foam original liquid trucks
- Ordinary fire engines
- Ambulances

Besides the above, movable powder chemical fire extinguishers are provided at major locations throughout the refinery.

Flare and Blowdown Systems

Provision is made for disposal of vapors and liquids discharged by various pressure-relieving devices such as safety valves, rupture disks, pressure-control valves, and furnace emergency blowdown valves.

Facilities included in these systems are an appropriately sized flare knockout drum, and a smokeless type flare stack with the following sizes corresponding to the refining capacities:

Table 5.13

Size of Flare Stack

Case:	125,000 BPSD	250,000 BPSD	500,000 BPSD
Diameter	36 inches	48 inches	48 inches
Height	80 m	80 m	110 m
Quantity	1	1	2

Sewer and Effluent Treatment Systems

Drainage from the refinery is collected in the three sewer systems being classified into process waste water, oily waste water and clean waste water. A part of process waste water, which contains H_2S and NH_3, is reused as desalting water in the atmospheric crude distillation unit after being treated in the foul water stripper for removal of H_2S and NH_3. Other process waste water is sent to a retained tank and then treated in multiple stages by the following effluent treatment facilities:

- CPI oil separator
- Coagulation settler
- Filter
- Incinerator

Oily storm water and blowdown waters from boilers and BFW treater are treated together with tanker deballasting water in CPI oil separator and coagulation filter.

The clean waste water including desalinator brine, cooling tower blowdown, and clean storm water is directly discharged into the guard basin. Then, all of the refinery effluent is gathered into the guard basin to retain and make the effluent uniform, and prevent large accidental discharge of contaminants. The quality requirements for waste water from the refinery are set as follows:

Table 5.14

Waste Water Quality

PH	5.8 - 8.6
COD	Max. 60 ppm
Oil	Max. 5.0 ppm
SS	Max. 30 ppm

Buildings and Equipment

Table 5.15 shows the planned buildings and their floor areas examined in the three cases of refining capacities.

The floor space for the warehouses and maintenance shop is so defined that the refinery can be essentially selfsufficient.

All of these buildings are completely furnished and air-conditioned.

Instrumentation and Information Control Systems

Operation of the refinery is centrally controlled, with instrument panels provided in the following control rooms:

- On-site Control Room
- Utility Control Room
- Off-site Control Room
- Shipping Control Room

Each instrument panel is provided with a semigraphic panel which indicates the process flow of related units to facilitate operation of the refinery. An electronic system is adopted for the instrument signal media.

The following information control system using electronic computers is installed in the refinery for the purpose of providing correct information related to the refinery operation and facilities status:

Table 5.15

Building Plan

Buildings			Total Floor Area, m^2		
	Stories	No.s	125,000 BPSD	250,000 BPSD	500,000 BPSD
Administ. Bldg.	2	1	3,000	3,000	3,400
Maintenance Shop	1	1	5,000	5,000	6,500
Warehouses	1	4	4,500	4,500	5,800
Laboratory	1	1	1,000	1,000	1,300
Eng'g Office	1	1	1,000	1,000	1,500
Control Rooms	1	5(7)	2,920	2,920	4,480
Power House	1	1	1,550	1,950	2,790
Costum House	1	1	90	90	90
Substations	1	25	4,600	6,910	12,330
Firehouse	1	1	600	600	600
Change House	1	1	500	500	750
Cafeteria	1	1	1,260	1,260	1,800
Clinic	1	1	300	300	300
Rest Houses	1	2	200	200	200
Gate Houses	1	3	140	140	140
Total	-	49(51)	26,660	29,370	41,980

( ): 500,000 BPSD Case

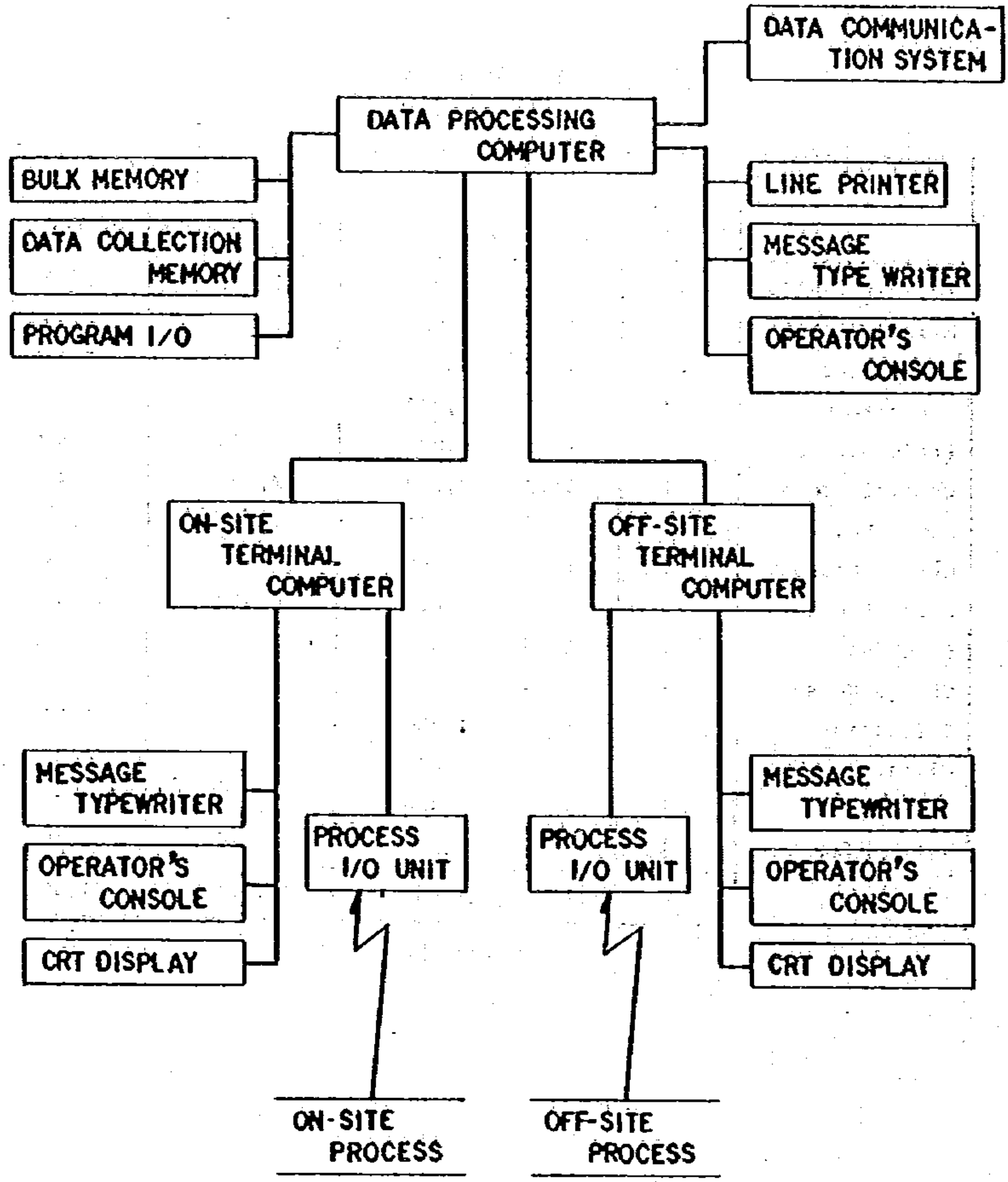


Figure 5.7

FLOW SCHEME FOR CONFIGURATION OF COMPUTER HARDWARE

- Shipment Control System
- Oil Inventory Control System
- Facilities Control System
- Cost Control System

The computer hardware comprises two computer terminals, one central processor, and their satellite installations as shown in Figure 5.7.

Civil Works

For preparation of the site in Mohammad Ameri, the ground is levelled at approximately 7 - 8 m above sea level.
The earth work volume for each refinery capacity is as shown below.

- 125,000 BPSD: 1,500,000 m^3
- 250,000 BPSD: 1,800,000 m^3
- 500,000 BPSD: 3,000,000 m^3

The soil of the site is composed of alternate strata of cohesive and sandy soils.
Because the subsurface soil is very stiff with the N value of 20 or more, piling is not required, and therefore, a spread footing type is selected.
As the soil along the Persian Gulf is, in general, corrosive containing sulfate, the Type-V cement is applied for the concrete foundation.
The tank foundations use an earth foundation type with crushed stones placed under shell plate.

The vicinities of process and utility facilities are paved with concrete.
Roads are paved with asphalt concrete and the width of pavement is 16 m for main roads and 6 m for secondary roads.
Chain-link fences are provided around the refinery property.

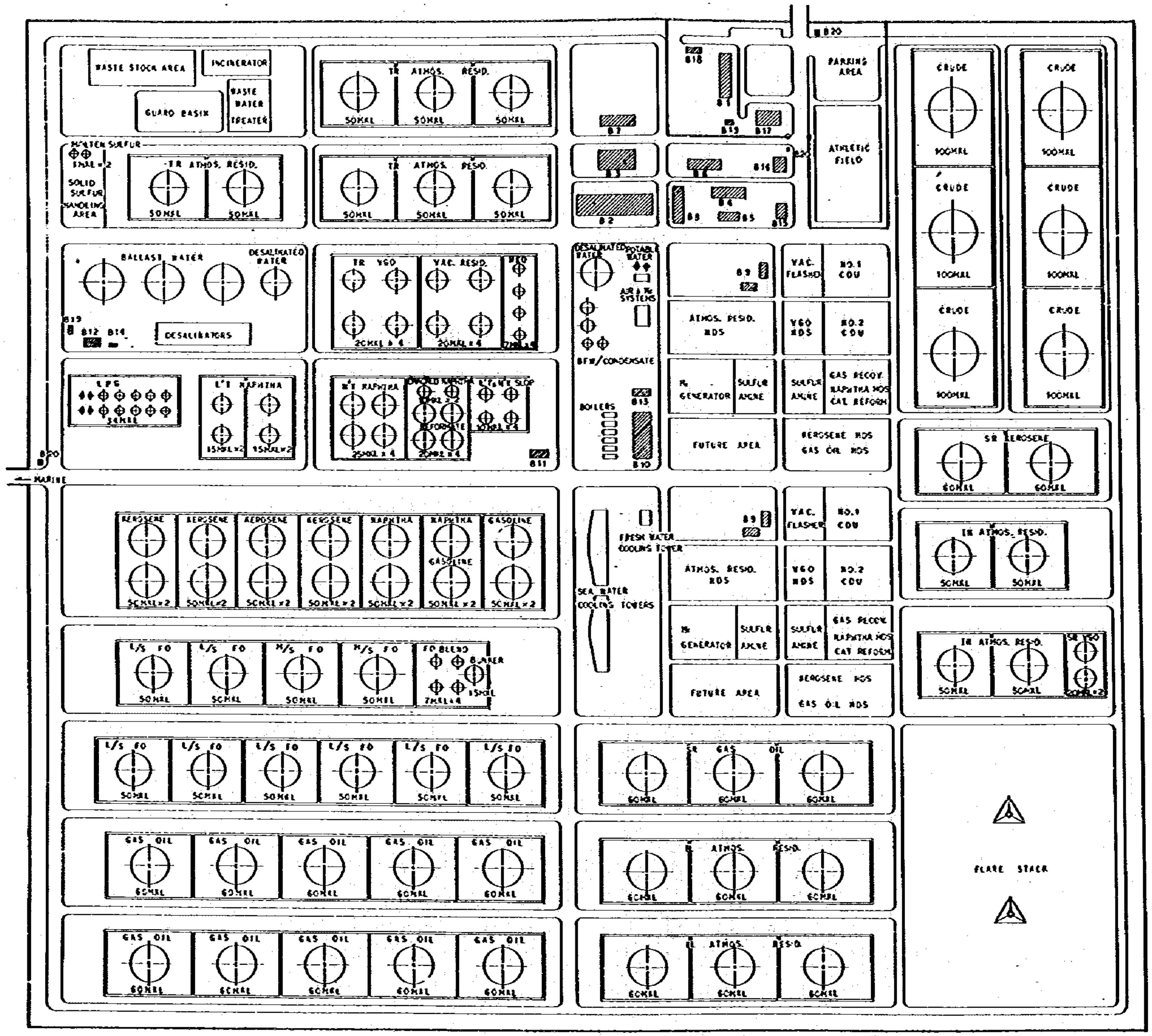
5.2.4 Refinery Plot Plan

A plot plan for the 500,000 BPSD of hydroskimming refinery is presented in Figure 5.8.
Basically the overall refinery site is considered as a group of general areas arranged to include crude storage, process units, intermediate storage, product storage, shipping, utilities, administration and service, and waste disposal.
The process units area in 500,000 BPSD is subdivided into two trains each capable of processing 250,000 BPSD crude oil.

The plot plans for the 125,000 BPSD and 250,000 BPSD cases will be essentially the same with the exception that the number of trains in process area and the area required for the crude and intermediate tankage.

The required area for each case is estimated as follows:

- 125,000: 2,130,000 m^2
- 250,000: 2,600,000 m^2
- 500,000: 4,230,000 m^2



BUILDINGS

B1 : ADMINISTRATION BUILDING
B2 : MAINTENANCE SHOP
B3 : SPARE WAREHOUSE
B4 : CATALYST WAREHOUSE
B5 : CHEMICAL WAREHOUSE
B6 : GENERAL WAREHOUSE
B7 : LABORATORY
B8 : ENGINEERING OFFICE
B9 : PROCESS CONTROL ROOMS (4)
B10 : UTILITY CONTROL ROOM
B11 : OFFSITE CONTROL ROOM
B12 : SHIPPING CONTROL ROOM
B13 : POWER HOUSE
B14 : CUSTOM HOUSE
B15 : FIRE HOUSE
B16 : CHANGE HOUSE
B17 : CAFETERIA
B18 : CLINIC
B19 : REST HOUSES (2)
B20 : GATE HOUSES (3)

REQUIRED AREA
$2{,}018^{M} \times 2{,}096^{M} = 4{,}230{,}000^{M^2}$

IRAN-JAPAN EXPORT REFINERY

REFINERY PLOT PLAN
HYDROSKIMMING : 500,000 BPSD
FIGURE 5.5

REFINERY

CASE 2 : HYDROCRACKING TYPE

5.3 Case 2: Hydrocracking Type Refinery

This section outlines the planned hydrocracking type refinery with three different capacities, namely, 125,000 BPSD, 250,000 BPSD, and 500,000 BPSD.

5.3.1 Process Units

As shown in the refinery flow scheme presented in Figure 5.9, this case represents a refinery with cracking processes such as the vacuum gas oil hydrocracker and the visbreaker. Thus the refinery processes the crude oils to increase the yields of middle distillates (naphtha, kerosene and gas oil).

The percentage yield of each salable products from this refinery is shown below:

Table 5.16

Product Yields of Case 2 Refinery

Products	Yields, Vol% on Crude
Gasoline	10.0
Naphtha	12.5
Kerosene	17.4
Gas Oil	24.9
Low Sulfur Fuel Oil	20.6
Medium Sulfur Fuel Oil	5.1
Bunker Fuel Oil	3.0
Total	93.5

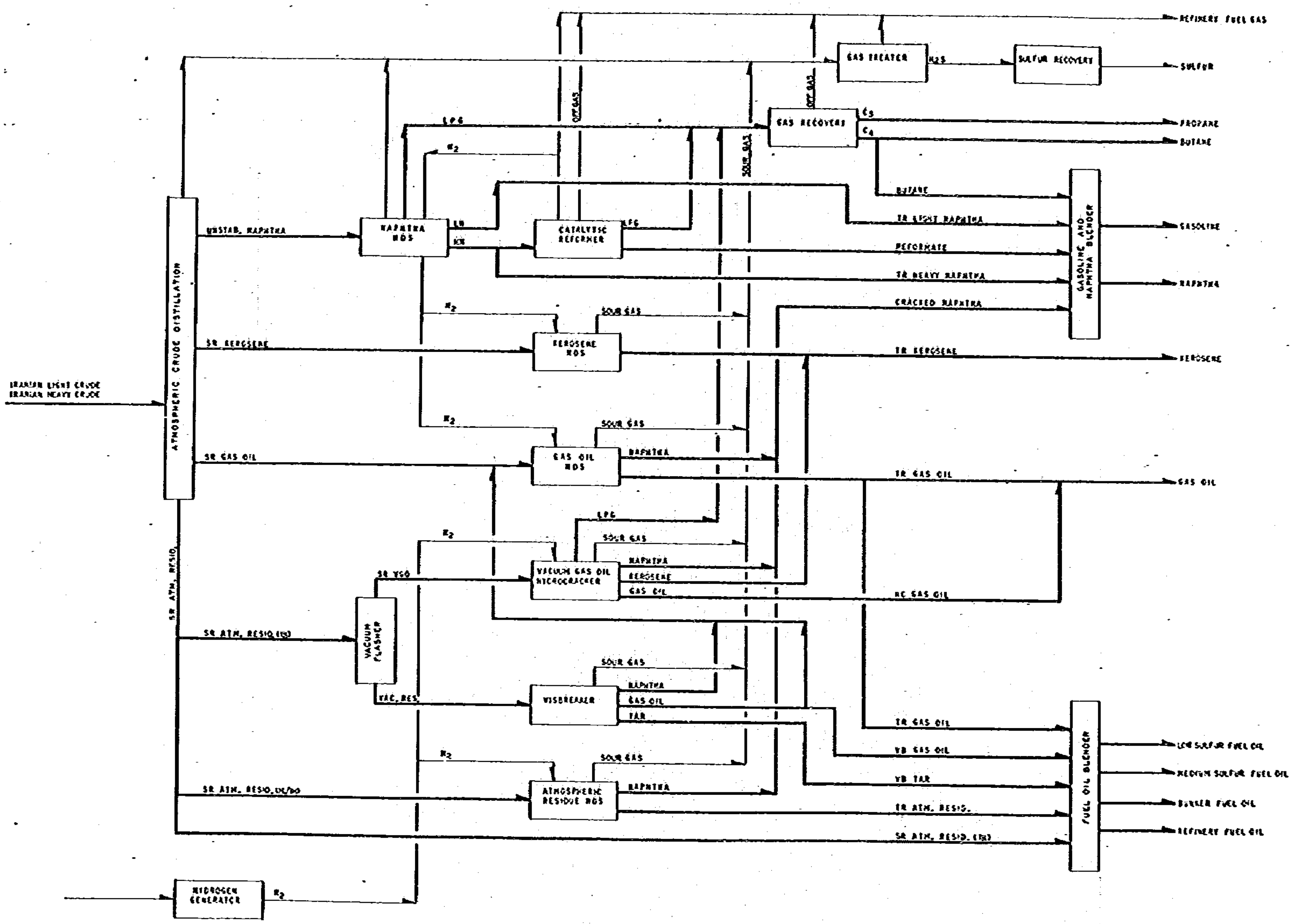
Further, production volumes of products for the three refining capacities are shown in Table 5.17 and a comparison between product specification and estimated actual properties of products obtained is shown in Table 5.18.

The Iranian light and Iranian heavy crude oils are fed to the respective atmospheric crude distillation units, and distilled at the following separation temperatures:

Table 5.17

Summary of Crude and Products
Case 2 Hydrocracking

	125,000 BPSD	250,000 BPSD	500,000 BPSD
	BPCD	BPCD	BPCD
1.Crude Oil			
Iranian Light Crude	53,125	106,250	212,500
Iranian Heavy Crude	53,125	106,250	212,500
Total	106,250	212,500	425,000
2.Products			
(1) Salable Products			
Gasoline	10,625	21,250	42,500
Naphtha	13,280	26,560	53,120
Kerosene	18,500	37,000	74,000
Gas Oil	26,455	52,910	105,820
L/S Fuel Oil (0.1%S)	21,845	43,690	87,380
M/S Fuel Oil (1.5%S)	5,460	10,920	21,840
Bunker Fuel Oil	3,190	6,380	12,760
Total	99,355	198,710	397,420
Sulfur	145 TPCD	290 TPCD	580 TPCD
(2) Refinery Use			
Off Gas	1,270 EFO	2,540 EFO	5,080 EFO
Propane	1,125	2,250	4,500
Butane	1,275	2,550	5,100
Refinery Fuel Oil	5,430	10,860	21,720



IRAN-JAPAN EXPORT REFINERY

BLOCK FLOW DIAGRAM
CASE-2: HYDROCRACKING
Figure 5.9

Table 5.18

Product Qualities Summary

Case 2 Hydrocracking

Products	Properties	Specification	Estimated Actual Value
Gasoline	Specific Gravity (15/4°C)	-	0.746
	RON, F-1 Clear	Min. 90	90
	RVP @37.8°C , Kg/cm²	0.45 - 0.63	0.63
	ASTM Distillation (D-86), °C		
	10%	Max. 65	44
	50%	Max. 120	76
	90%	Max. 180	145
	97%	Max. 205	166
Naphtha	Specific Gravity (15/4°C)	-	0.722
	RVP @37.8°C , Kg/cm²	Max. 0.63	0.63
	Sulfur Content , wt.%	Max. 0.01	0.01
	EP , °C	Max. 200	190
Kerosene	Specific Gravity (15/4°C)	-	0.802
	Flash Point (Tag) , °C	Min. 40	45
	Smoke Point , mm	Min. 24	24
	Sulfur Content , wt.%	Max. 0.005	0.005
	ASTM Distillation (D-86), °C		
	IBP	Min. 150	161
	95%	Max. 235	233
Gas Oil	Specific Gravity (15/4°C)	-	0.852
	Flash Point (P-M) , °C	Min. 50	113
	Pour Point , °C	Max. -7.5	-9.0
	Cetane No.	Min. 50	57
	Sulfur Content , wt.%	Max. 0.1	0.04
	ASTM Distillation (D-86), °C		
	90%	Max. 350	335
L/S Fuel Oil	Specific Gravity (15/4°C)	-	0.918
	Flash Point , °C	Min. 60	60
	Sulfur Content , wt.%	Max. 0.1	0.1
	Viscosity @50°C , cSt	Max. 150	40
M/S Fuel Oil	Specific Gravity (15/4°C)	-	0.942
	Flash Point , °C	Min. 60	60
	Sulfur Content , wt.%	Max. 1.5	1.5
	Viscosity @50°C , cSt	Max. 150	150
Bunker Fuel Oil	Specific Gravity (15/4°C)	-	0.962
	Sulfur Content , wt.%	Max. 3.5	2.6
	C.C.R. , wt.%	Max. 12	12.0
	Viscosity @50°C , cSt	Max. 250	250

Note: The estimated value of aromatics content in gasoline is 38 vol.%.

Naphtha	Less than 154°C
Kerosene	154 - 235°C
Gas Oil	235 - 371°C
Residue	Over 371°C

The overhead distillate from the atmospheric crude distillation units is treated in the naphtha hydrodesulfurizer and separated into LPG, light naphtha and heavy naphtha.

The separated light naphtha is run down to storage tanks and is blended into gasoline and product naphtha.
A part of the heavy naphtha is processed in the catalytic reformer into reformate with octane number of RON 98, while the remaining heavy naphtha is run down to storage tanks and blended into the product naphtha together with the light naphtha and cracked naphtha.

The LPG fraction from the naphtha hydrodesulfurizer, the catalytic reformer and the vacuum gas oil hydrocracker is fed to the gas recovery unit where propane and butane are separately recovered.
Of the recovered LPGs, all the propane is consumed as refinery fuel and as hydrogen plant feedstock, and butane is partly blended into gasoline and product naphtha within the vapor pressure specification limit. The remaining butane is entirely consumed as a fuel in the refinery, while no shipment as product.

The kerosene fraction from the atmospheric crude distillation units is directed to product kerosene tanks after being treated in the kerosene hydrodesulfurizer together with hydrocracked kerosene.

As for the gas oil fraction, although a part of it is used without further treatment as blending stock for medium sulfur fuel oil, most of the fraction is sent to gas oil pool after desulfurizing, together with hydrocracked gas oil.

The atmospheric residue from Iranian light crude oil is entirely hydrodesulfurized into fuel oil with a sulfur content of 0.1 wt.%.
While, the residue from Iranian heavy crude is routed to the following:

- Atmospheric residue hydrodesulfurizer together with Iranian light residue.
- Vacuum gas oil hydrocracker after vacuum flashing.
- Fuel oil blending.

The residue from vacuum flasher is fed to the visbreaker and thermally cracked into naphtha, gas oil and tar.

The sour gas streams from distillation, hydrodesulfurization and cracking units are amine washed for H_2S removal and sent to the refinery fuel system, while the recovered H_2S is fed to the sulfur recovery unit.

The hydrogen necessary for the naphtha, kerosene and gas oil hydrodesulfurizers is supplied from the catalytic reformer, from the hydrogen generator for the vacuum gas oil hydrocracker and atmospheric residue hydrodesulfurizer. The feedstock of hydrogen generator is refinery off-gas and recovered propane.

Installed Capacity

The capacity and number of units of the individual process units are defined for each refinery scale, i.e. 125,000, 250,000 and 500,000 BPSD by taking into account the operation and maintenance schedules.
The number of refining trains for each refinery scale is determined to be one for 125,000 and 250,000 BPSD and two for 500,000 BPSD.

Despite the above, the gas treating, sulfur recovery and hydrogen generator units are defined to have two independent units for refinery train to enable continuous service when one group is in maintenance, while the other group is in operation.

In defining the installed capacity of each process units, the following bases are used:

- An on-stream factor of 80 percents for the atmospheric residue hydrodesulfurizer.
- An on-stream factor of 85 percent for the other units.
- To cover Peak loads of hydrogen consumed and sour gas generated for hydrogen generator, gas treater and sulfur recovery.

The installed capacity of the process units is summarized in Table 5.19 for each refining scale.

5.3.2 Utilities System

One of the major factors essential to the successful operation of a grass-roots refinery is the reliable supply of the necessary utilities.

Table 5.19

Installed Capacities of Process Units

Case 2 Hydrocracking

Process Unit	Unit	125,000 BPSD		250,000 BPSD		500,000 BPSD	
		Capacity	No.s	Capacity	No.s	Capacity	No.s
Atmospheric Crude Distillation	BPSD	125,000 *)	1	125,000	2	125,000	4
Vacuum Flasher	BPSD	19,300	1	38,500	1	38,500	2
Gas Recovery	BPSD	4,700	1	9,400	1	9,400	2
Naphtha Hydrodesulfurizer	BPSD	26,500	1	52,900	1	52,900	2
Catalytic Reformer	BPSD	9,700	1	19,300	1	19,300	2
Kerosene Hydrodesulfurizer	BPSD	17,700	1	35,300	1	35,300	2
Gas Oil Hydrodesulfurizer	BPSD	28,900	1	57,700	1	57,700	2
Vacuum Gas Oil Hydrodesulfurizer	BPSD	-	-	-	-	-	-
Vacuum Gas Oil Hydrocracker	BPSD	9,900	1	19,700	1	19,700	2
Atmospheric Residue Hydrodesulfurizer	BPSD	30,300	1	60,600	1	60,600	2
Visbreaker	BPSD	9,400	1	18,800	1	18,800	2
Hydrogen Generator	$10^6 Nm^3/SD$	0.55	2	1.10	2	1.10	4
Gas Treater	TPSD (as H_2S)	100	2	200	2	200	4
Sulfur Recovery	TPSD (as S)	90	2	180	2	180	4
Foul Water Stripper	TPSD	1,120	1	2,230	1	2,230	2

*) Dual Flasher Type

Based on the prevailing local conditions of Muhammad Ameri, the integrated system and facilities for supplying these services are investigated and defined.
Particular attentions are given to the reliability of the system, and the stable supply of the utilities on a self-supporting basis.

Overall Supply System

The overall system diagram for steam, power, and water is presented in Figure 5.10.
The refinery generates and consumes steam at three pressure levels as follows:

- High pressure steam - 43 Kg/cm^2G, 400°C
- Medium pressure steam - 15 Kg/cm^2G, 270°C
- Low pressure steam - 3.5 Kg/cm^2G, Saturate

High pressure steam generated in the oil fired boilers is consumed is steam turbines for power generation and as motive steam for the major gas compressors in the catalytic reformer, vacuum gas oil hydrocracker, and atmospheric residue hydrodesulfurizer as well as for driving refinery air compressors.
The medium pressure steam is generated from waste heat boilers equipped in the catalytic reformer and hydrogen generator and also is extracted from the power generation turbines.
It is consumed as motive steam for small drivers and as heating and atomizing steams.
Low pressure steam is generated from waste heat boilers and exhausted from steam turbines, and is consumed as deaeration steam for boiler feed water and also as heating and stripping steam for various equipment.

The extracting-condensing turbines are adopted for electric power generation.
The balance of medium pressure requirements can be adequately supplied by controlling the rate of extraction, while the supply of power demand can be kept easily by controlling the rate of steam to be condensed.
Steam condensate is collected where practicable, and recirculated after filtered.

Two kinds of cooling water system are provided, one is the sea water cooling for the services where applicable to the maximum extent and the other is the fresh water cooling system. Both systems are designed to save the make-up waters by adopting a recirculating system through the individual cooling towers.

The refinery uses the three types of fuels as follows:

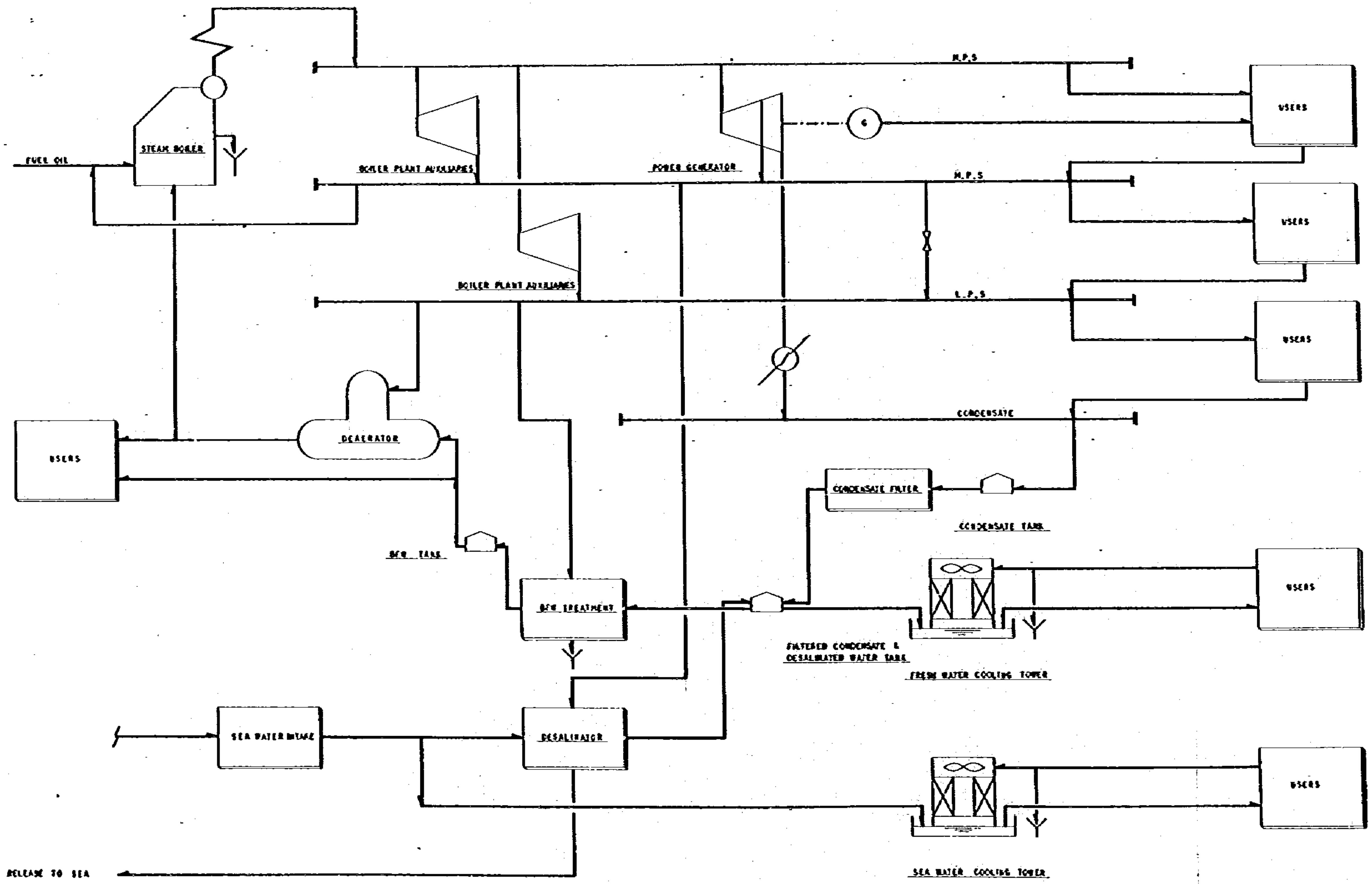
- Refinery off gas
- LPG
- Heavy fuel oil

Gases from various process units are collected and sweetened in the amine gas treating unit and then sent to the mixing drum. LPG from storage is also sent to the mixing drum through the LPG vaporizer to sustain the mixed fuel gas at a predetermined heating value. While, home fuel oil normally used is a visbreaker tar of Iranian heavy crude. The oil is drawn from the storage tank and pumped to boilers and process furnaces after being heated up to 160°C.
Provision is made for the system to recirculate the oil to attain stable supply.

The air compressors to supply the instrument air and the plant air are provided as required. Furthermore, inert gas generators of air separation type are provided to supply the entire refinery's demand.

Utilities Balance

Table 5.20 shows the utilities balance in the case of a refinery capacity of 250,000 BPSD on calendar day basis (yearly average).
This table indicates the consumption and generation rates of utilities such as electric power, fuel, three pressure level steams, sea-water, fresh water, steam condensate, pure water, boiler feed water for each units in the refinery.
Positive values indicated in the table represent consumption, while negative values for generation. Utilities requirements for each refinery capacity are summarized in Table 5.21.



IRAN-JAPAN EXPORT REFINERY

STEAM, POWER AND WATER SYSTEM DIAGRAM

Figure 6.10

Table 5.20

Utility Balance (Case 2 Hydrocracking 250,000 BPSD)

	Elec. Power	Fuel	Steam			Water		Steam Cond.	B.F.W.	
			H.P.	M.P.	L.P.	Sea	Fresh		Cold	Hot
	KW	10^6 Kcal/CD	Ton/CD	Ton/CD	Ton/CD	10^3 Ton/CD	Ton/CD	Ton/CD	Ton/CD	Ton/CD
Atmos. Crude Distillation	4,480	2,801		970	327	40.8	1,224	-458		
Vacuum Flasher	740	694		231	- 26	18.5	261			112
Gas Recovery	110				182	25.0	192	-182		
Naphtha HDS	1,720	1,372		43		32.6	605			156
Cat. Reformer	270	1,178	377	-319	-377	30.6	113			360
Kerosene HDS	1,400	576		72		40.4	391			125
Gas Oil HDS	3,440	1,128		130	12	69.7	770			218
Atmos. Residue HDS	10,880	1,102	739	- 91	-636	92.9	3,020	-219		835
Hydrocracker	4,630	898	401	-266	-346	6.0	400			377
Visbreaker	310	845		139	-1,008	18.4	214			1,032
Gas Treating	320			72	1,157	18.3	46	-1,229		10
Sulfur Recovery	720	254			- 72	2.3	46	-144		895
Hydrogen Plant	1,700	2,724		-271	242	14.7	1,272	- 55	2,659	
Foul Water Stripper	200				540	17.8		-516		
On-Site Total	30,920	13,572	1,517	710	-657	428.0	8,554	-2,803	2,659	4,120
Off-Site Total	3,000		216	480	672	2.6	552	-120		
Steam Generator		7,781	-9,072	-898	-768					
Deaerator					2,237				13,013	11,129
Power Generator	-37,220		5,496	-1,065		221.5		-4,430		-15,249
BFW Treatment	330				58			15,790	-15,672	
Desalinator	640				1,074			-9,574		
Sea Water Intake	1,260									
SW Cooling Tower	1,050		1,817		-1,817	-652.1				
FW Cooling Tower	20		26		- 26		-9,106	1,137		
Utility Total	-33,920	7,781	-1,733	-1,963	758	-430.6	-9,106	2,923	-2,659	-4,120
Refinery Grand Total	0	21,353	0	-773	773	0.0	0	0	0	0

Notes: 1) Sea water Intake: 173,000 Ton/CD
2) Positive figures mean consumption, while negative figures for production.

Table 5.21

Summary of Utility Requirements

Case 2 Hydrocracking

Requirement	Unit	125,000 BPSD	250,000 BPSD	500,000 BPSD
Electric Power	KW	18,700	37,300	74,600
Total Fuel	10^6Kcal/CD	10,700	21,400	42,800
Steam	TON/CD	5,500	10,900	21,800
Cooling Sea Water	TON/CD	326,000	652,000	1,304,000
Cooling Fresh Water	TON/CD	4,600	9,100	18,200
Net Boiler Feed Water	TON/CD	4,300	8,500	17,000
Net Sea Water Intake	TON/CD	86,500	173,000	346,000

Installed Capacity

The capacities of the individual utility facilities are defined on an operating day basis taking into account the peak loads (normal maximum). For the major facilities shown below, one unit is provided for stand-by service:

- Steam boiler
- Electric power generator
- Sea water desalinator
- Polisher
- Cooling water circulation pump
- Air compressor

The installation summary of the utilities system for each refinery capacity is presented in Table 5.22.

5.3.3 Offsite Facilities

Tankage and Blending Facilities

The planned oil handling system of the refinery is illustrated in the tank flow diagram, Figure 5.11.

Both Iranian light and Iranian heavy crude oils are delivered by the two crude oil pipelines and stored in separate tanks which are capable of accomodating full plant requirements for seven days' normal operation.

The following process intermediate tankage is provided to enable to continue its operation when the other units are shut down for maintenance or catalyst regeneration and replacement.

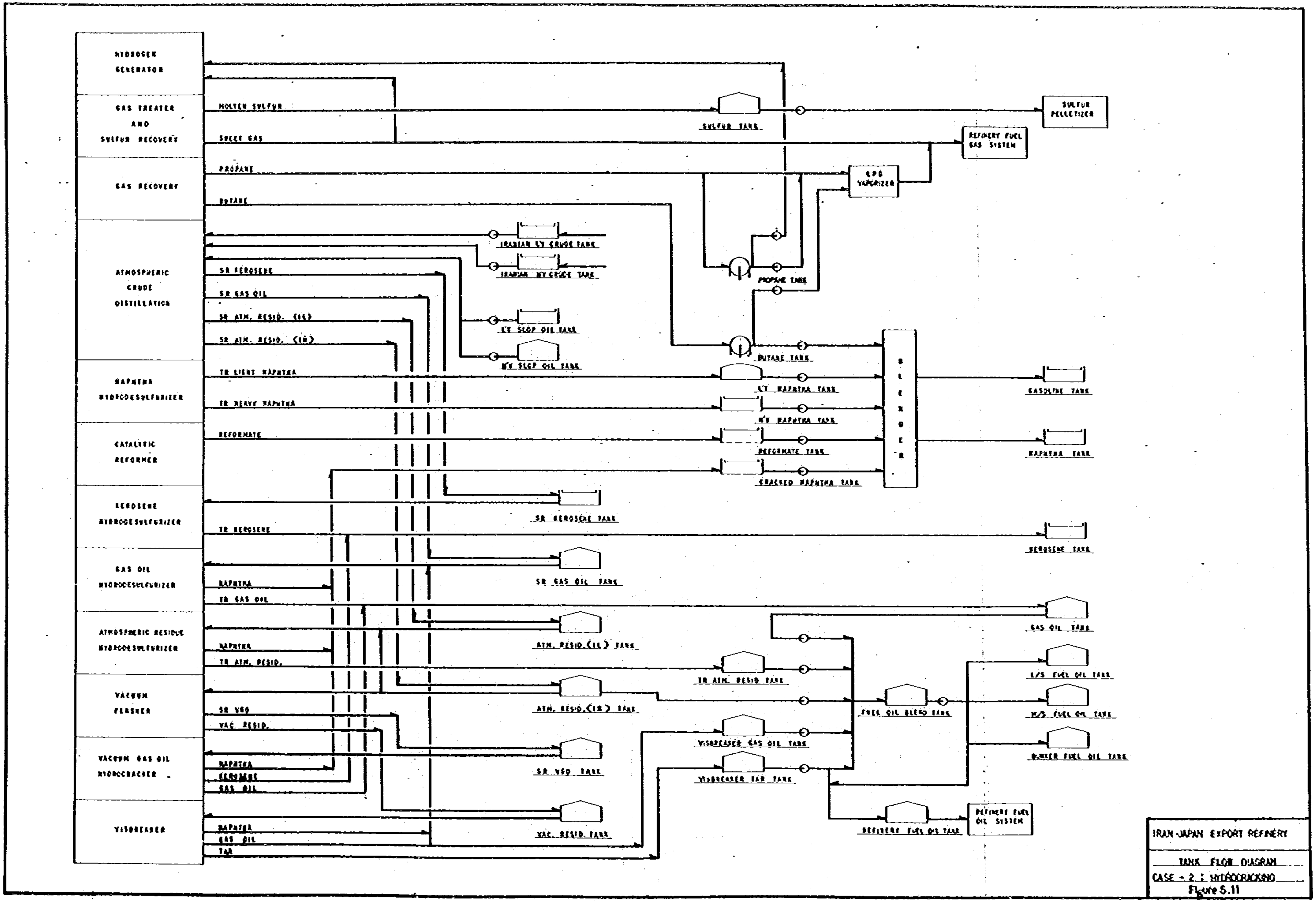
Stream	Process Unit Charged	Storage Days
SR Kerosene	HDS	18
SR Gas Oil	HDS	18
SR VGO	HDS	7
Atm. Residue (IL/IH)	HDS	18
Vac. Residue (IH)	Visbreaker	7

The component oil before blending and finished products leaving the process units run into large semi-product and product tanks respectively. Total product tankage capacities including those for semi-products before blending are defined to be for 30 days minimum and, in principle, 15 days' capacity for semi-product.

Table 5.22

Installation Summary: Utility Facilities
Case 2 Hydrocracking

Facility	125,000 BPSD		250,000 BPSD		500,000 BPSD		Remarks
	Capacity	No.s	Capacity	No.s	Capacity	No.s	
1. Steam Generator	170 Ton/Hr	3	310 Ton/Hr	3	400 Ton/Hr	4	44 Kg/cm^2G, 410°C One unit for stand-by
2. Power Generator	15,000 KW	3	17,000 KW	4	21,000 KW	6	Extracting-condensing One unit for stand-by
3. Desalinator	2,700 Ton/day	3	5,200 Ton/day	3	10,200 Ton/day	3	One unit for stand-by
4. BFW Treatment							
- Condensate Filter	140 Ton/Hr	2	260 Ton/Hr	2	340 Ton/Hr	3	
- Mixed Bed Polisher	240 Ton/Hr	3	460 Ton/Hr	3	600 Ton/Hr	4	One unit for stand-by
- Water Tanks							
a) Condensate Tank	1,500 KL	2	3,000 KL	2	5,000 KL	2	
b) Filtered Cond. & Desal.W.Tank	12,000 KL	2	25,000 KL	2	45,000 KL	2	
c) BFW Tank	3,000 KL	2	5,000 KL	2	10,000 KL	2	
5. Cooling Water System							
- Sea Water Cooling Tower	20,000 M^3/Hr	1	19,000 M^3/Hr	2	19,000 M^3/Hr	4	
- Fresh Water Cooling Tower	300 M^3/Hr	1	600 M^3/Hr	1	1,100 M^3/Hr	1	
6. Sea Water Intake							
- Pumps	3,000 M^3/Hr	3	5,500 M^3/Hr	3	7,000 M^3/Hr	4	One pump for stand-by
- Piping	34 inch (6,000 M^3/Hr)	1	42 inch (11,000 M^3/Hr)	1	54 inch (21,000 M^3/Hr)	1	
7. Air System	1,500 Nm^3/Hr	3	2,000 Nm^3/Hr	3	2,000 Nm^3/Hr	5	
8. Inert Gas System	250 Nm^3/Hr	2	500 Nm^3/Hr	2	1,000 Nm^3/Hr	2	
9. Fuel Oil Pump	45 Ton/Hr	3	90 Ton/Hr	3	170 Ton/Hr	3	One pump for stand-by
10. Fuel Gas System							
11. Potable Water System							
- Chlorinator	10 Ton/Hr	1	10 Ton/Hr	1	20 Ton/Hr	1	
- Tank	1,000 KL	1	1,000 KL	1	1,000 KL	2	



HYDROGEN GENERATOR
GAS TREATER AND SULFUR RECOVERY
GAS RECOVERY
ATMOSPHERIC CRUDE DISTILLATION
NAPHTHA HYDRODESULFURIZER
CATALYTIC REFORMER
KEROSENE HYDRODESULFURIZER
GAS OIL HYDRODESULFURIZER
ATMOSPHERIC RESIDUE HYDRODESULFURIZER
VACUUM FLASHER
VACUUM GAS OIL HYDROCRACKER
VISBREAKER
MOLTEN SULFUR
SWEET GAS
PROPANE
BUTANE
SR KEROSENE
SR GAS OIL
SR ATM. RESID. (LL)
SR ATM. RESID. (HH)
TR LIGHT NAPHTHA
TR HEAVY NAPHTHA
REFORMATE
TR KEROSENE
NAPHTHA
TR GAS OIL
NAPHTHA
TR ATM. RESID.
SR VGO
VAC. RESID.
NAPHTHA
KEROSENE
GAS OIL
NAPHTHA
GAS OIL
TAR
SULFUR TANK
SULFUR PELLETIZER
REFINERY FUEL GAS SYSTEM
LPG VAPORIZER
IRANIAN LT CRUDE TANK
IRANIAN HY CRUDE TANK
PROPANE TANK
LT SLOP OIL TANK
HY SLOP OIL TANK
BUTANE TANK
LT NAPHTHA TANK
HY NAPHTHA TANK
REFORMATE TANK
CRACKED NAPHTHA TANK
BLENDER
GASOLINE TANK
NAPHTHA TANK
SR KEROSENE TANK
KEROSENE TANK
SR GAS OIL TANK
GAS OIL TANK
ATM. RESID. (LL) TANK
TR ATM. RESID TANK
ATM. RESID. (HH) TANK
FUEL OIL BLEND TANK
L/S FUEL OIL TANK
H/S FUEL OIL TANK
VISBREAKER GAS OIL TANK
BUNKER FUEL OIL TANK
SR VGO TANK
VISBREAKER TAR TANK
VAC. RESID. TANK
REFINERY FUEL OIL TANK
REFINERY FUEL OIL SYSTEM
IRAN-JAPAN EXPORT REFINERY
TANK FLOW DIAGRAM
CASE - 2 : HYDROCRACKING

Figure 5.11

Furthermore, product tankage is defined to have a capacity not less than 1.5 times of one shipment by the maximum size product carrier.

The tankage for other services is defined based on the following:

. Bunker fuel oil	15 days
. Refinery fuel oil	6 days
. Refinery propane	5 days
. Liquid sulfur	3 days

The planned tankage for each case is summarized in Table 5.23.
The tanks in the above table include a 15 percent safety factor.

Component oils stored in individual semi-product tanks are blended into the desired products with a schedule as shown in Table 5.24.
Blending of gasoline and naphtha is performed by the commonly installed in-line blender. Based on each blending plan in the table, the required components are pumped simultaneously at controlled rates into a blending header.
Blending of fuel oils is carried out by in-line blending followed by blending tanks where further adjustments are performed and then transferred to product tanks.

Products Shipping System

The products are pumped from product tanks to a marine loading terminal by means of pipelines over a total distance of 19 Km covering 4 Km of on-shore causeway and 15 Km of submarine from the end of the causeway as shown in Figure 5.12.
Tanker loading time at the sea berth is assumed to be 18 hours for a ship of 130,000 DWT for white oils and 24 hours for a ship of 200,000 DWT for black oils.
Three pipelines are provided for white oil loadings, i.e., one line for gasoline and naphtha, one line for kerosene and gas oil and one line for common use.
One common pipeline is provided for low sulfur fuel oil and medium sulfur fuel oil shipping.
This line is scheduled to be flushed with gas oil after loading operation to prevent set up of heavy oils in the line.

Table 5.23

Tankage Summary: Case 2 Hydrocracking

Service	125,000 BPSD		250,000 BPSD		500,000 BPSD		Remarks
	No.s	Capacity,KL	No.s	Capacity,KL	No.s	Capacity,KL	
1. Crude Oil Tanks							
Iranian Light Crude	2	37,500	2	75,000	3	100,000	FRT
Iranian Heavy Crude	2	37,500	2	75,000	3	100,000	FRT
2. Intermediate Tanks							
Straight Run Kerosene 1)	1	60,000	2	60,000	2	60,000	FRT
Straight Run Gas Oil 1)	2	50,000	4	50,000	4	50,000	CRT
Atmospheric Residue (IL) 2)	2	40,000	3	60,000	6	60,000	CRT
Atmospheric Residue (IH)	2	30,000	2	40,000	4	40,000	CRT
Straight Run Vacuum Gas Oil	1	15,000	1	25,000	2	25,000	CRT
Vacuum Residue	1	15,000	1	25,000	2	25,000	CRT
3. Semi-Product Tanks							
Propane	3	500	3	1,000	6	1,000	SPH
Butane	3	3,000	6	3,000	12	3,000	SPH
Light Naphtha	2	10,000	2	15,000	4	15,000	DRT
Heavy Naphtha	2	15,000	2	25,000	4	25,000	FRT
Reformate	2	10,000	2	20,000	4	20,000	FRT
Cracked Naphtha	2	10,000	2	15,000	4	15,000	FRT
Treated Atmospheric Residue	2	50,000	3	60,000	6	60,000	CRT
Visbreaker Gas Oil	1	3,000	1	5,000	2	5,000	CRT
Visbreaker Tar	2	10,000	2	20,000	4	20,000	CRT
4. Product Tanks							
Gasoline	2	60,000	2	60,000	2	60,000	FRT
Naphtha	3	60,000	3	60,000	3	60,000	FRT
Kerosene	2	60,000	4	60,000	8	60,000	FRT
Gas Oil	3	60,000	6	60,000	12	60,000	CRT
Low Sulfur Fuel Oil	5	60,000	5	60,000	5	60,000	CRT
Medium Sulfur Fuel Oil	2	40,000	2	40,000	2	40,000	CRT
Bunker Fuel Oil	1	15,000	1	15,000	1	15,000	CRT
5. Other Service Tanks							
Refinery Fuel Oil	2	4,000	2	7,000	4	7,000	CRT
Fuel Oil Blending	2	5,000	2	10,000	4	10,000	CRT
Light Slop Oil	1	10,000	1	10,000	2	10,000	FRT
Heavy Slop Oil	1	10,000	1	10,000	2	10,000	CRT
Molten Sulfur	1	500	1	1,000	2	1,000	CRT
Grand Total	57	1,737,000	70	2,676,000	119	4,337,000	

Notes: 1) Interchangeable with Product Tanks
2) Common for Intermediate and Semi-Product Tanks

Table 5.24

Products Blending Table

Case2: Hydrocracking 250,000 BPSD

Blending Component	BPCD	Refinery Fuel Gas	Gasoline	Naphtha	Kerosene	Gas Oil	L/S Fuel Oil	M/S Fuel Oil	Bunker Fuel Oil	Refinery Fuel Oil
Off Gas	2,535 (EFO)	2,535 (EFO)								
Propane	2,247	2,247								
Butane	5,046	2,554	726	1,766						
Treated Light Naphtha	9,987		7,486	2,501						
Treated Heavy Naphtha	14,241			14,241						
Reformate	13,038		13,038							
Cracked Naphtha	8,051			8,051						
Treated Kerosene	29,963				29,963					
Hydrocracked Kerosene	7,044				7,044					
Treated Gas Oil	46,453					45,849		604		
Hydrocracked Gas Oil	7,061					7,061				
Visbreaker Gas Oil	1,540								1,540	
Straight Run Atmos.Residue(IH)	9,286							5,859	3,427	
Treated Atmos. Residue	48,147						43,688	4,459		
Visbreaker Tar	12,264								1,408	10,856
Total	216,903	7,336	21,250	26,559	37,007	52,910	43,688	10,922	6,375	10,856

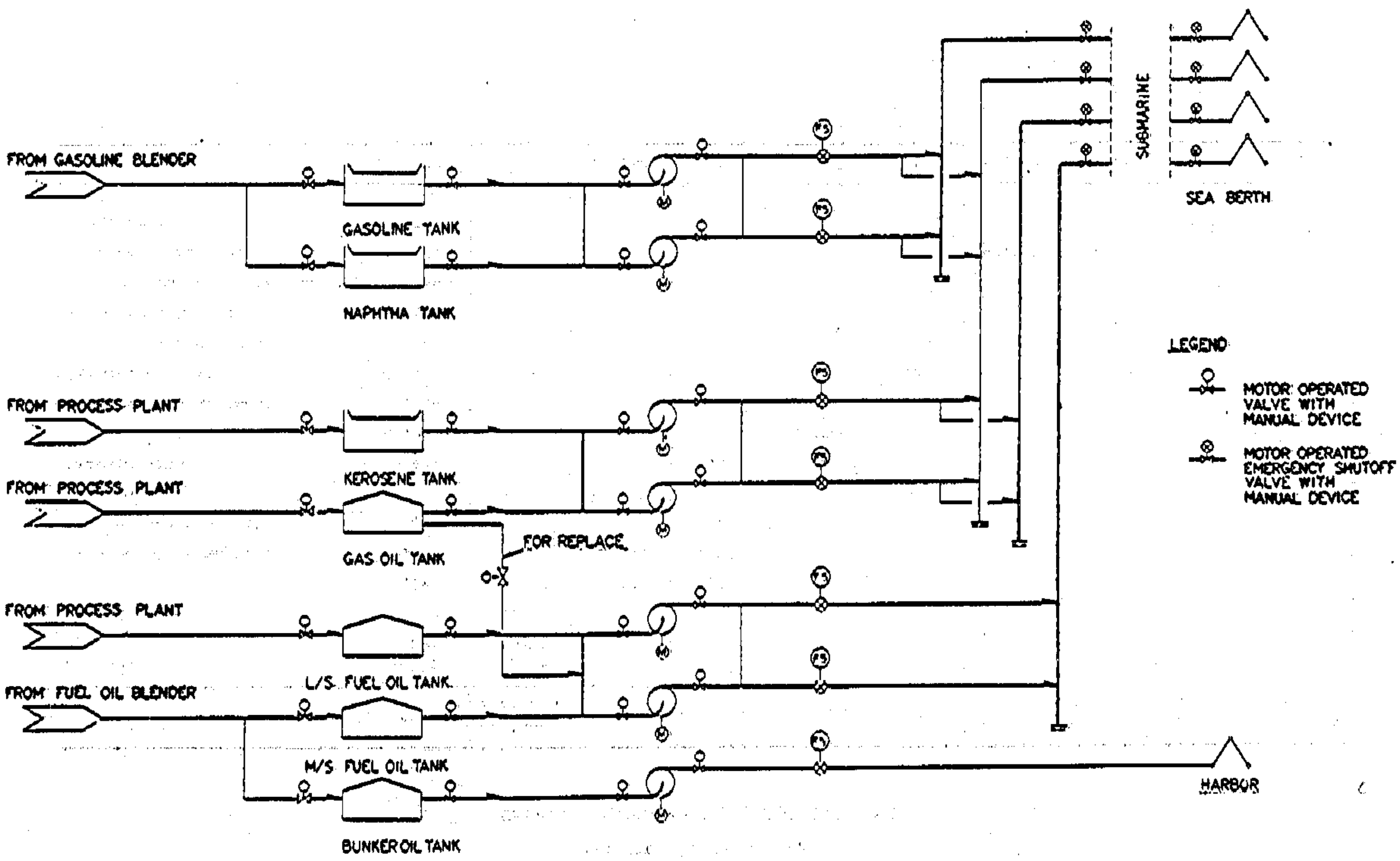


Figure 5. 12
SIMPLIFIED FLOW DIAGRAM
FOR
PRODUCT SHIPPING FACILITY

One pipeline for supplying potable water to tankers and one pipeline to discharge deballasting water from tankers are provided additionally. While, the ship's bunker fuel oil is transported from the refinery to the harbor through on-shore pipeline and then delivered to tankers by means of barges.

Table 5.25 represents the planned capacity of the shipping pumps and the size of the pipelines .

Solid Sulfur Handling System

The molten sulfur stored in the high temperature sulfur tank is pelletized for shipment. The pelletized sulfur is temporarily stored outdoors in piled form and then transported by means of the conveyor belt along the causeway to the sulfur shipping wharf located at the end of the causeway and 4 Km far from the refinery.
Based on the operation schedule that operating hours of the pelletizer are eight (8) hours per day and the maximum tonnage of a sulfur carrier is 10,000 DWT, this system is defined to be made up as shown in Table 5.26.

Catalyst Loading and Unloading System

The atmospheric residue hydrodesulfurizer requires catalyst replacement at every six months intervals.
On this occasion, spent and deteriorated catalyst is withdrawn from the reactor and hauled away by truck after packing into drums.
On this occasion, spent and deteriorated catalyst is withdrawn from the reactor and hauled away by truck after packing into drums.
On the other hand, fresh catalyst is lifted to the level of the charging ports with bucket elevators and loaded into the reactor by means of conveyor belt. The volume of catalyst replaced and the time required are estimated for a 60,000 BPSD of the atmospheric residue hydrodesulfurization unit (reactor 2 trains).

- Catalyst replaced: Annually 390 Ton x 2 Times
- Required time : 15 days per time

Fire-fighting System

A fire water system to store, pump, and distribute sea water throughout the plant for fire protection and fire-fighting is provided.
Water for the fire service is drawn from the sea water intake pit and pumped up to the water distribution header.

Table 5.25

Installed Capacity of Product Shipping System

Service	Shipping Pumps	Pipelines
Gasoline Naphtha Kerosene Gas Oil	5,000 m^3/H x 4	32 inches x 3
L/S Fuel Oil H/S Fuel Oil	5,000 m^3/H x 2	42 inches x 1
Bunker Fuel Oil	1,000 m^3/H x 2	16 inches x 1
Potable Water	50 m^3/H x 2	4 inches x 1
Ballast Water	-	22 inches x 1

Table 5.26

Installed Capacity of Solid Sulfur Handling System

Case :	125,000 BPSD	250,000 BPSD	500,000 BPSD
Sulfur Pelletizer	20 Ton/H	40 Ton/H	80 Ton/H
Storage Yard	5,500 m^2	5,500 m^2	5,500 m^2
Conveyor Belt	500 Ton/H	500 Ton/H	500 Ton/H

Three 410 m^3/H fire water pumps including one spare pump (one electric motor driven, two diesel driven) are provided to distribute fire water to hydrants and turrets spaced strategically to protect all areas of the the plant. The hydraulic pressure at each fire hydrant is maintained at 7 Kg/cm^2G.

For the high pressure gas facilities in the LPG spherical tank area, water sprays are provided.

The refinery has a self-defence fire-fighting system centralized in the fire station where the following vehicles are provided:

- Foam fire engines
- Powder fire engines
- Foam original liquid trucks
- Ordinary fire engines
- Ambulances

Besides the above, movable powder chemical fire extinguishers are provided at major locations throughout the refinery.

Flare and Blowdown Systems

Provision is made for disposal of vapors and liquids discharged by various pressure-relieving devices such as safety valves, rupture disks, pressure-control valves, and furnace emergency blowdown valves. Facilities included in these systems are an appropriately sized flare knockout drum, and a smokeless type flare stack with the following sizes corresponding to the refining capacities:

Table 5.27

Size of Flare Stack

Case:	125,000 BPSD	250,000 BPSD	500,000 BPSD
Diameter	36 inches	48 inches	48 inches
Height	80 m	80 m	110 m
Quantity	1	1	2

Sewer and Effluent Treatment Systems

Drainage from the refinery is collected in the three sewer systems being classified into process waste water, oily waste water and clean waste water.

A part of process waste water, which contains H_2S and NH_3, is reused as desalting water in the atmospheric crude distillation unit after being treated in the foul water stripper for removal of H_2S and NH_3.

Other process waste water is sent to a retained tank and then treated in multiple stages by the following effluent treatment facilities:

- CPI oil separator
- Coagulation settler
- Filter
- Incinerator

Oily storm water and blowdown waters from boilers and BFW treater are treated together with tanker deballasting water in CPI oil separator and coagulation filter.

The clean waste water including desalinator brine, cooling tower blowdown, and clean storm water is directly discharged into the guard basin.

Then, all of the refinery effluent is gathered into the guard basin to retain and make the effluent uniform, and prevent large accidental discharge of contaminants.

The waste water quality from the refinery is defined as follows:

Table 5.28

Waste Water Quality

PH	5.8 - 8.6
COD	Max. 60 ppm
Oil	Max. 5.0 ppm
SS	Max. 30 ppm

Buildings and Equipment

Table 5.29 shows the planned buildings and their floor areas examined in the three cases of refining capacities.

The floor space for warehouses and maintenance shop is so defined that the refinery can be essentially self-sufficient.
All of three buildings are completely furnished and air-conditioned.

Instrumentation and Information Control Systems

Operation of the refinery is centrally controlled, with instrument panels provided in the following control rooms:

- On-site Control Room
- Utility Control Room
- Off-site Control Room
- Shipping Control Room

Table 5.29

Building Plan

Buildings			Total Floor Area, m^2		
	Stories	No.s	125,000 BPSD	250,000 BPSD	500,000 BPSD
Administ. Bldg.	2	1	3,000	3,000	3,400
Maintenance Shop	1	1	5,000	5,000	6,500
Warehouses	1	4	4,500	4,500	5,800
Laboratory	1	1	1,000	1,000	1,300
Eng'g Office	1	1	1,000	1,000	1,500
Control Rooms	1	5(7)	2,920	2,920	4,480
Power House	1	1	1,550	1,950	2,790
Costum House	1	1	90	90	90
Substations	1	25	4,600	6,910	12,330
Firehouse	1	1	600	600	600
Change House	1	1	500	500	750
Cafeteria	1	1	1,260	1,260	1,800
Clinic	1	1	300	300	300
Rest Houses	1	2	200	200	200
Gate Houses	1	3	140	140	140
Total	-	49(51)	26,660	29,370	41,980

( ): 500,000 BPSD Case

Each instrument panel is provided with a semigraphic panel which indicates the process flow of related units to facilitate operation of the refinery. An electronic system is adopted for the instrument signal media.

The following information control system using electronic computers is installed in the refinery for the purpose of providing correct information related to the refinery operation and facilities status:

- Shipment Control System
- Oil Inventory Control System
- Facilities Control System
- Cost Control System

The computer hardware comprises two computer terminals, one central processor, and their satellite installations as shown in Figure 5.13.

Civil Works

For preparation of the site in Mohammad Ameri, the ground is levelled at approximately 7 - 8 m above sea level.
The earth work volume for each refinery capacity is as shown below.

- 125,000 BPSD : 1,600,000 m^3
- 250,000 BPSD : 1,900,000 m^3
- 500,000 BPSD : 3,200,000 m^3

The soil of the site is composed of alternate strata of cohesive and sandy soils.
Because the subsurface soil is very stiff with the N value of 20 or more pilling is not required, and therefore, a spread footing type is selected.
As the soil along the Persian Gulf is, in general, corrosive containing sulfate, the Type-V cement is applied for the concrete foundation.
The tank foundations use an earth foundation type with crushed stones placed under shell plate.

The vicinities of process and utility facilities are paved with concrete.
Roads are paved with asphalt concrete and the width of pavement is 16m for main roads and 6m for secondary roads.
Chain-link fences are provided around the refinery property.

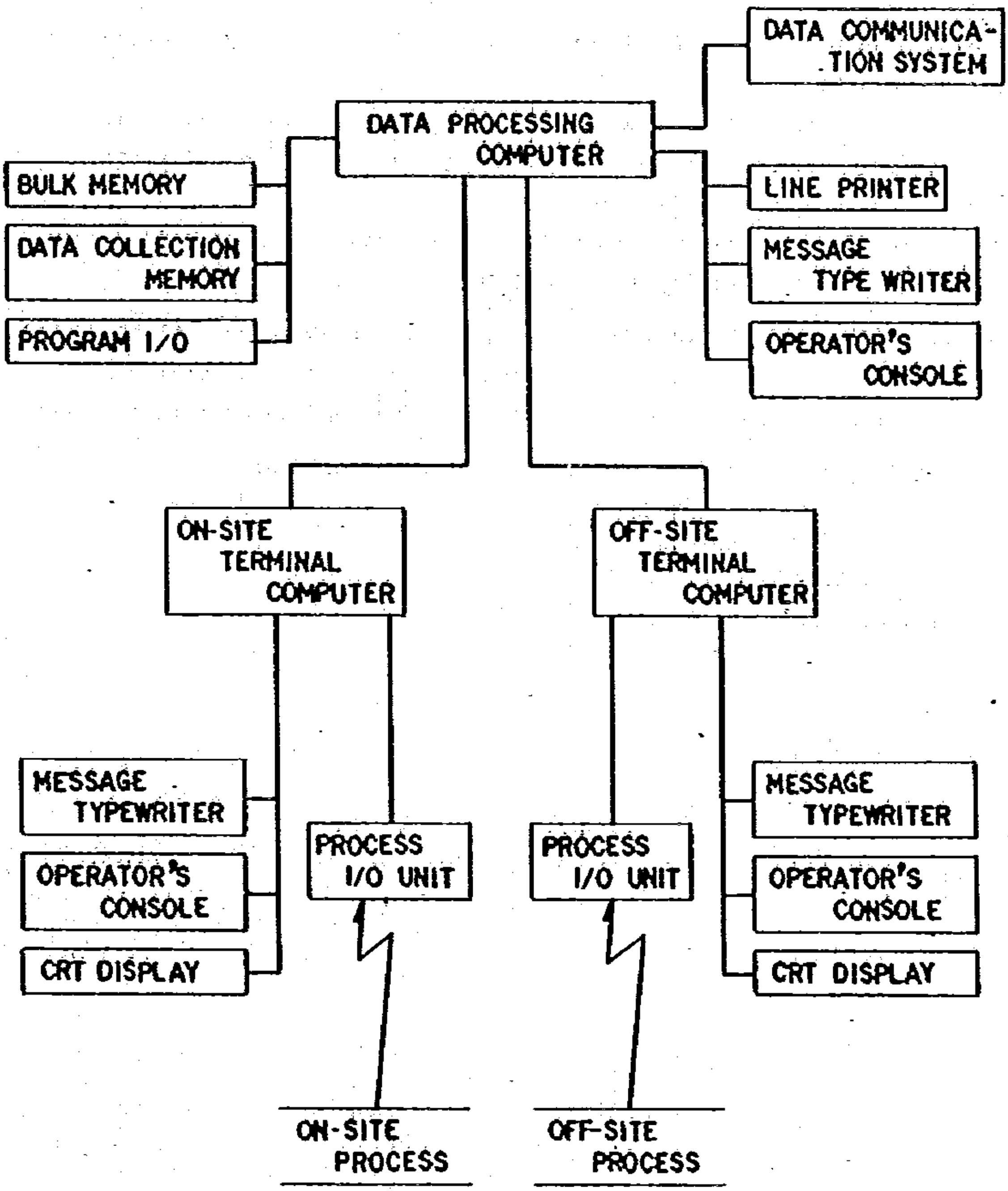


Figure 5.13

FLOW SCHEME FOR CONFIGURATION OF COMPUTER HARDWARE

5.3.4 Refinery Plot Plan

A plot plan for the 500,000 BPSD of hydrocracking refinery is presented in Figure 5.14.

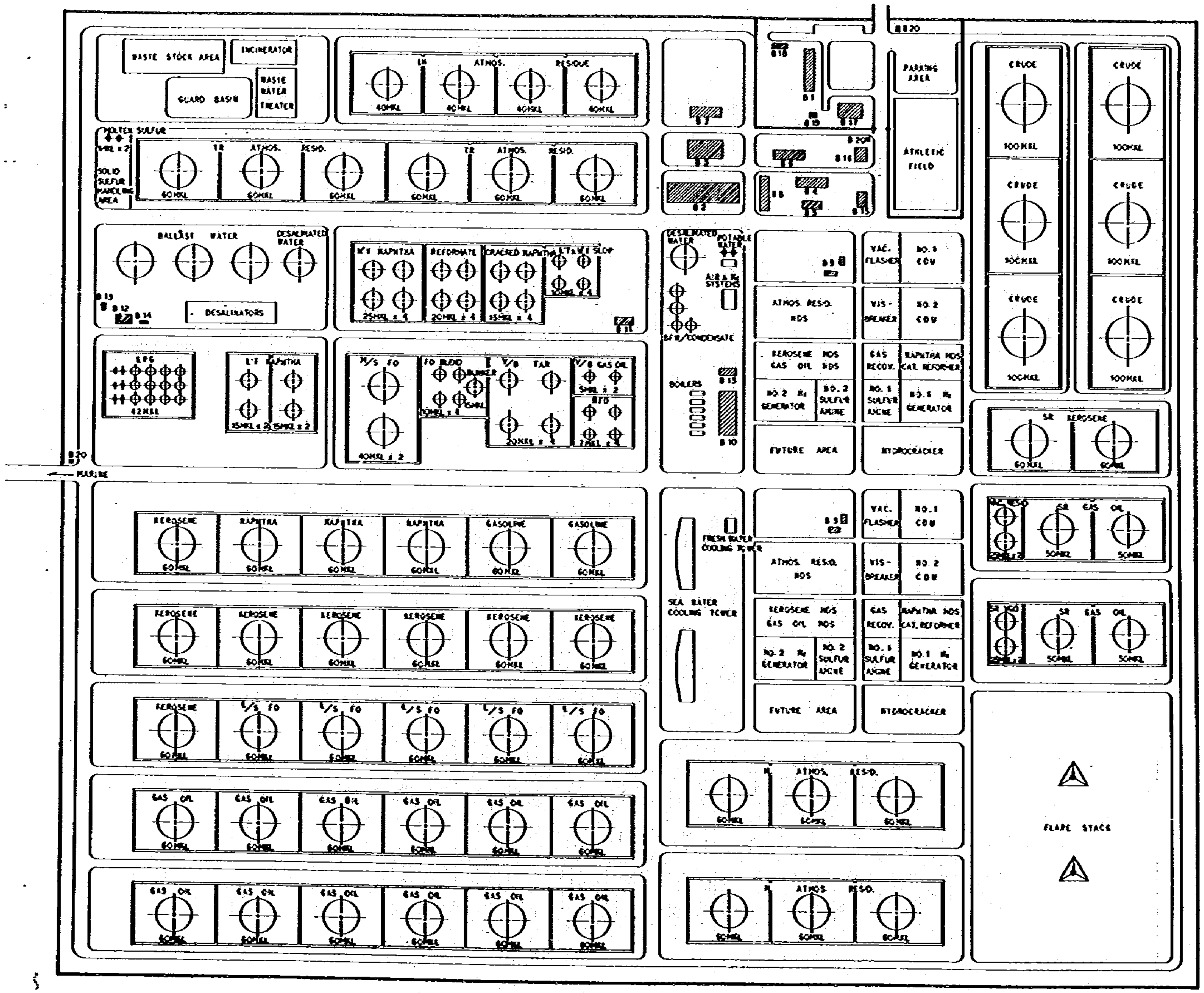
General areas arranged to include crude storage, process units, intermediate storage, product storage, shipping, utilities, administration and service, and waste disposal.

The process units area in 500,000 BPSD is subdivided into two (2) trains each capable of processing 250,000 BPSD crude oil.

The plot plans for the 125,000 BPSD and 250,000 BPSD cases will be essentially the same with the exception that the number of trains in process area and the area required for the crude and intermediate tankage.

The required area for each case is estimated as follows:

- 125,000 BPSD : 2,290,000 m^2
- 250,000 BPSD : 2,790,000 m^2
- 500,000 BPSD : 4,540,000 m^2



BUILDINGS

- B1 : ADMINISTRATION BUILDING
- B2 : MAINTENANCE SHOP
- B3 : SPARE WAREHOUSE
- B4 : CATALYST WAREHOUSE
- B5 : CHEMICAL WAREHOUSE
- B6 : GENERAL WAREHOUSE
- B7 : LABORATORY
- B8 : ENGINEERING OFFICE
- B9 : PROCESS CONTROL ROOMS (4)
- B10 : UTILITY CONTROL ROOM
- B11 : OFFSITE CONTROL ROOM
- B12 : SHIPPING CONTROL ROOM
- B13 : POWER HOUSE
- B14 : COSTUM HOUSE
- B15 : FIRE HOUSE
- B16 : CHANGE HOUSE
- B17 : CAFETERIA
- B18 : CLINIC
- B19 : REST HOUSES (2)
- B20 : GATE HOUSES (3)

REQUIRED AREA
2,018M x 2,248M = 4,540,000

IRAN-JAPAN EXPORT REFINERY

REFINERY PLOT PLAN

HYDROCRACKING : 500,000 BPSD

FIGURE 5.14

MARINE FACILITIES

5.4 Marine Facilities

As illustrated in Figure 5.15, the following marine facilities for product shipment are constructed in the nearest sea area to the refinery:

- Sea Berth
- Harbor and Dredged Channel
- Causeway
- Sea Water Intake Facility

Most of products from the refinery are shipped at the sea berth which can accommodate 200,000 DWT product tankers and tankers as small as 50,000 DWT through the product submarine pipelines.

Shipment of solid sulfur and bunker fuel oil, which are poor in fluidity, is conducted at the harbor by carriers up to 10,000 DWT for sulfur and 5,000 DWT for bunker fuel oil.

In locating these marine facilities, due considerations are made on the directions of prevailing wind, wave, and tidal current in the sea area for attaining safe navigation and anchorage of product carriers.

5.4.1 Sea Berth

A sea berth which can accommodate large size tankers up to 200,000 DWT is constructed at a point, 18.8 Km offshore from the coastline near the refinery, with a water depth of 20 m.

A fixed platform sea berth shown in Figure 5.16 is adopted for the plan because of ease of tanker steering and reliability of the facilities. The facility comprises a loading platform, breasting dolphin, mooring dolphin and catwalks for connecting them.

The superstructures for the loading platform and mooring dolphin is a steel construction and that for the breasting dolphin is of reinforced concrete. Steel pipe pile is used for the substructure of these installations.

The prevailing wind direction in the sea area is northwest and tidal current is in the almost same direction.
From the above viewpoint, the normal line of sea berth is decided to be in the axis of northwest - southeast.

Twin berth will be adopted for the 500,000 BPSD capacity refinery, while single berth for the 125,000 or 250,000 BPSD capacity.

5.4.2 Harbor and Dredged Channel

At 3.5 Km offshore of the refinery where the water depth is 3 m, a harbor will be constructed for loading solid sulfur and bunker fuel oil, unloading general cargoes and accommodating various small boats such as tugboats, fire boats, and launches.

A dredged channel with 10 m depth and 200 m width will be constructed to permit ships of maximum tonnage of 10,000 DWT to pass through it to the harbor.
It will be required to dredged about a distance of 9 Km.

A general plot plan of the harbor is presented in Figure 5.17.
As shown in the figure, the major sizes of the harbor facilities are as summarized below:

- Sulfur loading wharf (up to 10,000 DWT)
  - 10 m water depth, 210 m quaywall length
- Bunker oil berth (up to 5,000 DWT)
  - 8 m water depth
- Common wharf (up to 1,000 DWT)
  - 8 m water depth, 140 m quaywall length
- Small boat pier
  - 8 m water depth, 185 m pier length

The anchorage area is planned to be enough to provide these vessels with safe sailing and anchoring as well as to permit the greatest vessel, 10,000 DWT sulfur carrier to turn in this area.
At the normal steering of 10,000 DWT carrier, two tugboats for arrival and one for departure is used.
Based on it, 350 m wide area of the turning basin, that will be enough for 10,000 DWT vessel to turn, is secured.

To always keep the anchorage area calm, a breakwater is constructed to shelter the area from the northwest predominant waves.

5.4.3 Causeway

A causeway with a crown width of 20 m will be constructed as a connecting path between the refinery and the harbor, on which the following provisions

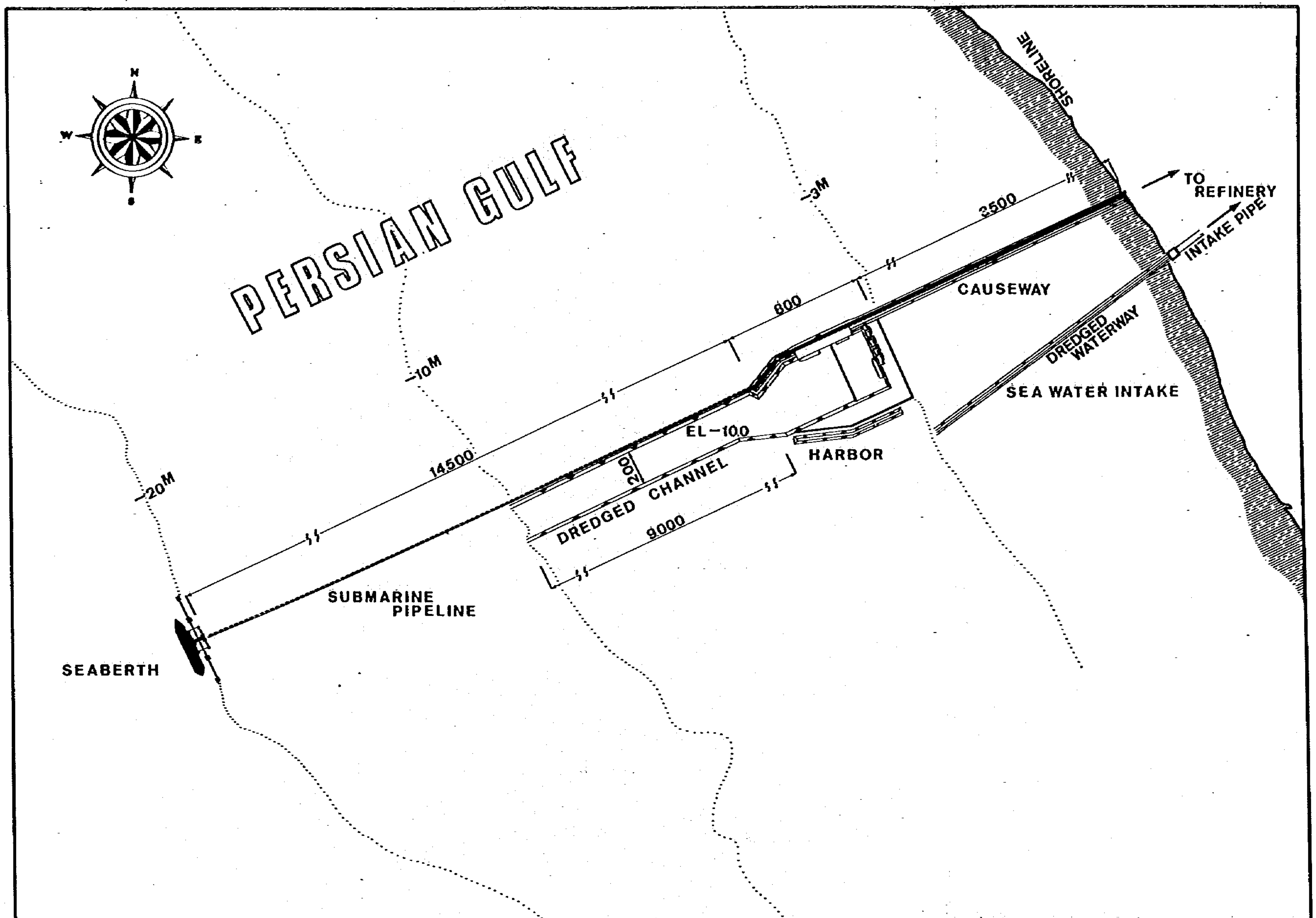


Fig 5.15

GENERAL LAYOUT OF MARINE FACILITIES

are made:

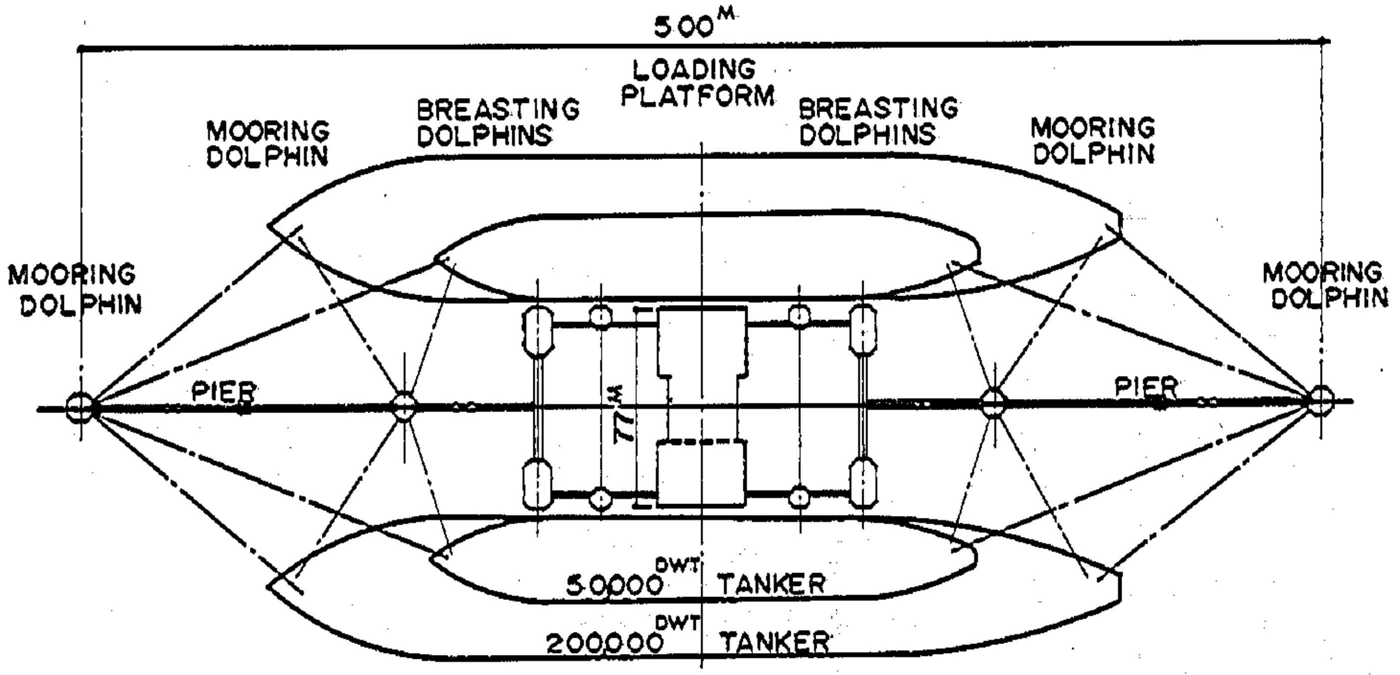
- Access road with 6 m width
- Lane for pipelines with 10 m width
- Lane for sulfur conveyor belt with 4 m width

As shown in the general section of the causeway of Figure 5.18, the embankment is mounted by riprap and on which cobble and armor stones with 0.5 to 4 tons weight are covered to reinforce it.
While the crown levee surface is paved with concrete to withstand possible overtopping waves.

It is expected that all of the embanking materials will be brought from an inland quarry.

5.4.4 Sea Water Intake Facility

From a point of 3 m water depth to the shoreline where a sea water intake pit will be installed, exclusive dreged waterway will be constructed.
The waterway is planned to be located to be south of the causeway to avoid the northwest predominant wave.



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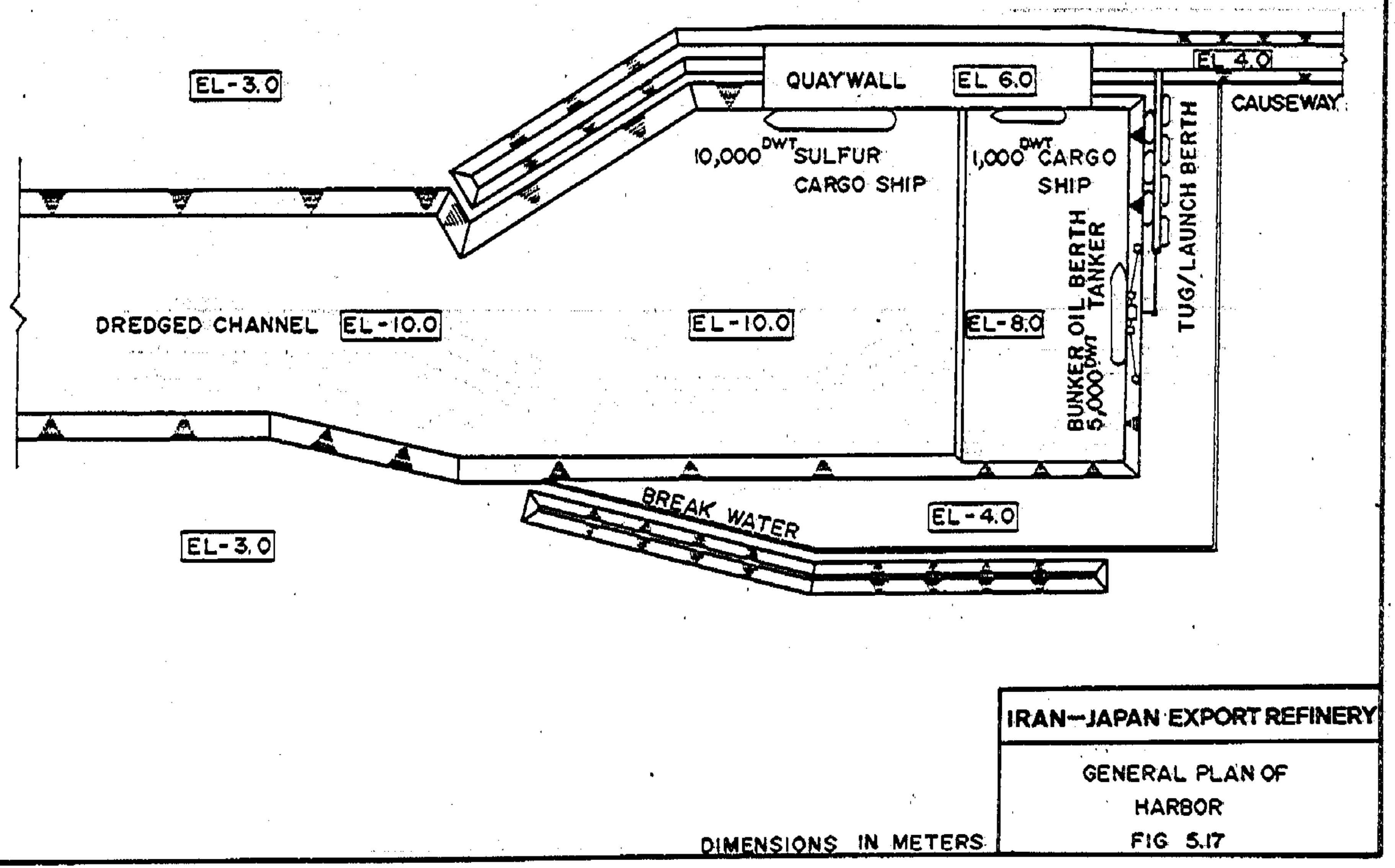
GENERAL PLAN OF
SEA BERTH
FIG 5.16



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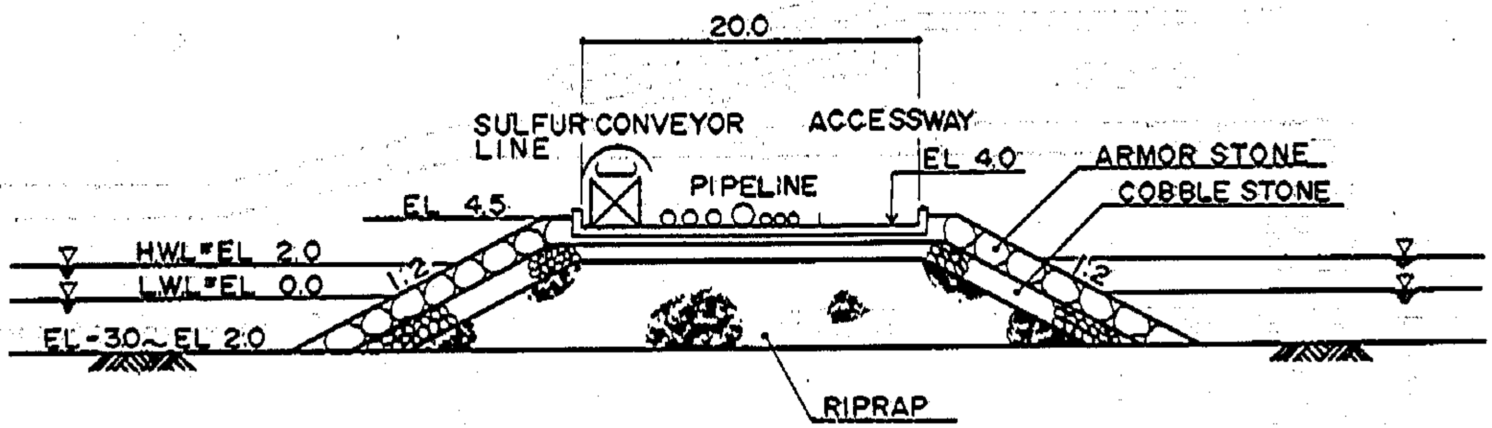
GENERAL PLAN OF HARBOR

FIG 5.17



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GENERAL SECTION OF CAUSEWAY

FIG 5.18