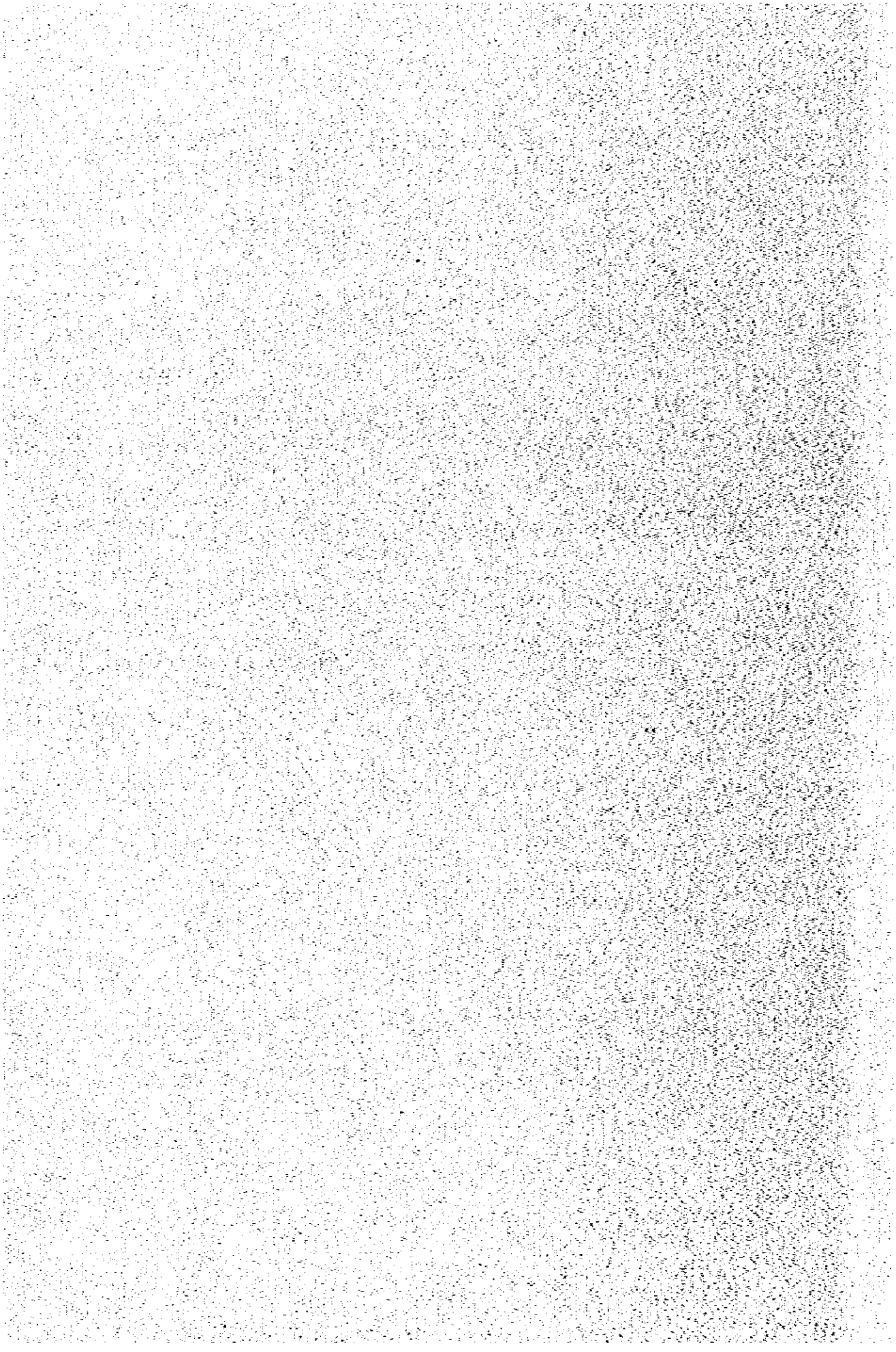
ANNEX III-2

MAJOR EQUIPMENT LIST



(1) Vacuum Distillation Unit

Vacuum Tower
L't Waxy Distillate Stripper
Med. Waxy Distillate Stripper
H'y Waxy Distillate Stripper
Slop Oil Drum
Vacuum Charge Heater
Sour Water Stripper
Sour Water Surge Drum
Acid Gas KO Drum

(2) Propane Deasphalting Unit

Extractor
DAO Flash Tower
DAO Stripper
Asphalt Flash Tower
Asphalt Stripper
Propane Accumulator
Compressor Suction KO Drum
Blowdown Drum
Surge Drum
Propane Compressor
Asphalt Heater

(3) Furfural Extraction Unit

Extractor
Raffinate Stripper
Raffinate Flash Tower
Extract Stripper
Extract Atmos. Flash Tower
Extract Press. Flash Tower
Furfural Tower
Water Tower
CBM Drum
Vacuum Accumulator
Furfural Tank
Inert Gas Holder

(4) Hydrofinishing Unit

Reactor
Stripper
Dryer
MEA Absorber
MEA Regenerator
High Pressure Separator
Low Pressure Separator
Hot Well Drum
Surge Drum
Make-up Gas Suction Drum
Recycle Gas Suction Drum
MEA Regenerator Reflux Drum
Fresh MEA Tank
Reactor Charge Heater
Stripper Charge Heater

(6) MEK Dewaxying Unit

DO Atmos. Flash Tower
DO Press. Flash Tower
DO Stripper
SW Atmos. Flash Tower
SW Press. Flash Tower
SW Stripper
MEK Tower
Filter Feed Drum
Filterate Receiver
Solvent Receiver
SW Mix Surge Drum
DO Mix Surge Drum
Propane Compressor Suction Drum
Propane Receiver
Inert Gas Holder
Solvent Tank
Charge Mix Chiller
Charge Mix Exchanger

Propane Compressor
Vacuum Pump
Rotary Vacuum Filter

(6) Visbreaking Unit

Fractionator
Feed Surge Drum
Fractionator Overhead Receiver
Visbreaker Heater
Decoking Pit

(7) Asphalt Blowing Unit

Oxidizer
Oil Scrubber
Buffer Drum
Spent Gas KO Drum
Air Blower
Charge Heater
Fume Incinerator

(8) Hot Oil System

Hot Oil Expansion Drum
Fuel Gas KO Drum
Hot Oil Heater

(9) Sulfur Recovery Unit

Reactor
Main Burner
Line Burner
Incinerator
Air Blower

ANNEX III-3

CODES AND STANDARDS

A. CRUDE OIL PIPELINE

ANSI B31.4	US Standard Code for Liquid Petroleum Transportation Piping System
ANSI B16.5	Forged Flanges
ANSI B16.9	Welding Fittings
MSS SP44	Large Diameter Flanges
API RP-5LI	Recommended Practice for Railroad Transportation of Line Pipe
API STD 1104	Standard for Welding Pipelines and Related Facilities
API SPEC 6D	Specification of Pipeline Valves
API RP-500C	Recommended Practice for Classification of Areas for Electrical Installation at Petroleum and Gas Pipeline Transportation Facilities
API RP-1102	Recommended Practice for Liquid Petroleum Crossing Railroads and Highways
API RP-1100	Recommended Practice for Pressure Testing of Liquid Petroleum Pipelines
API RP-1109	Recommended Practice for Marking Petroleum Pipeline Facilities
DOT PART 195	Minimum Federal Safety Standards for Liquid Pipelines
API 5L	API Specification for Line Pipe
API 5LX	API Specification for High - Test Line Pipe

B. REFINERY AND MARINE FACILITIES

1 Standards for Tanks and Pressure Vessels

1)	JPI	Japanese Petroleum Institute
2)	API 650	Welded Steel Tanks for Oil Storage
3)	API 620	Design and Construction of Large Welded, Low-Pressure Storage Tanks
4)	ANSI B96.1	Welded Aluminum-Alloy Field-Erected Storage Tanks
5)	ASME	Boiler and Pressure Vessel Code Sect. VIII div. 1 & 2
6)	ASME	Sect. I Power Boilers Sect. II Material Specification Sect. IV Low Pressure Heating Boilers Sect. IX Welding Qualifications
7)	API 2550	Method for Measurement and Calibration of Upright Cylindrical Tank
8)	BS 1515	Pressure Vessels for Chemical Petroleum and Allied Industries
9)	DIN	Deutscher Normenausschus
10)	AD - Merkblatt	
11)	TRD	Technische Regal für Damptkessel
12)	BS 1500	Pressure Vessels

2 Rotating Equipment Standards

1)	API 610	Centrifugal Pumps for General Refinery Services
2)	API 611	General-Purpose Steam Turbines for Refinery Services
3)	API 612	Special-Purpose Steam Turbines for Refinery Services
4)	API 613	High-Speed, Special-Purpose Gear Units for Refinery Services
5)	API 615	Mechanical-Drive Steam Turbines for General Refinery Services
6)	API 616	Combustion Gas Turbines for General Refinery Services
7)	API 617	Centrifugal Compressors for General Refinery Services
8)	API 618	Reciprocating Compressors for General Refinery Services
9)	ASME PTC 7.1	Displacement Pumps
10)	ASME PTC 8.2	Centrifugal Pumps
11)	ASME PTC 9	Displacement Compressor, Vacuum Pumps and Blowers
12)	ASME PTC 10	Centrifugal Compressor

3 Heat Exchanger Standards

Shell and Tube Heat Exchangers

1) TEMA Class R

2) API 660 — Heat Exchanger for General Refinery Services

Air-Cooled Heat Exchangers

1) API 661 — Air-Cooled Heat Exchangers for General Refinery Services

4 Instrumentation Standards

1)	API RP500A	Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries
2)	API RP550	Manual on Installation of Refinery Instruments and Control Systems
3)	API 1101	Measurement of Petroleum Liquid Hydrocarbons by Positive Displacement Meter
4)	API 2000	Venting Atmospheric and Low Pressure Storage Tanks
5)	API 2545	Method of Gauging Petroleum and Petroleum Products
6)	API RP500C	Recommended Practice for Classification of Areas for Electrical Installation at Petroleum and Gas Pipe Line Transportation Facilities
7)	API 2531	Mechanical Displacement Meter Provers
8)	ANSI C1	National Electrical Code (NEC) (NFPA NO. 70)
9)	NEMA	National Electrical Manufacturers Association
10)	NFPA 493	Intrisically Safe Process Control Equipment for Use in Hazardous Location
11)	NFPA 496	Purged Enclosures for Electrical Equipment
12)	IEC	International Electro Technical Commission

5 Electrical Standards

1)	NEC	The National Electrical Code
2)	API RP500A	Recommended Practice for Classification of Areas for Electrical Installations in Petroleum Refineries
3)	API RP540	Recommended Practice for Electrical Installation in Petroleum Refineries
4)	API RP2003	Recommended Practice for Protection Against Ignitions Arising Out of Static, Lighting and Stray Currents
5)	NEMA	National Electrical Manufacturers Association Standares
6)	NFPA 493	Standard for Intrisically Safe Process Control Equipment for Use in Hazardous Location
7)	NFPA 496	Standard for Purged and Ventilated Enclosures for Electrical Equipment in Hazardous Locations
8)	API RP500C	Recommended Practice for Classification of Areas for Electrical Installation at Petroleum and Gas Pipeline Transportation Facilities

6 Structural, Building, and Foundation Standards

1)	ACI	American Concrete Institute
2)	AISC	American Institute of Steel Construction
3)	AIJ	Architectural Institute of Japan
4)	JASS	Japanese Architectural Standard Specification
5)	CEIJ	Civil Engineer Institute of Japan

7 Mechanical Equipment Standard

1) CTI Cooling Tower Institute

1) NFPA The National Fire Protection Assn.

9 Piping Standards and Codes

1)	ANSI B31.3	US Standard Code for Petroleum Refinery Piping System
2)	ANSI B31.4	US Standard Code for Liquid Petroleum Transportation Piping System
3)	ANSI B16.5	Forged Flanges
4)	ANSI B16.9	Welding Fittings
5)	MSS SP44	Large Diameter Flanges
6)	API 5L	Specification for Line Pipe
7)	API 5LX	Specification for High-Test Line Pipe
8)	API RP5L1	Recommended Practice for Railroad Transportation of Line Pipe
9)	API SP6D	Spcification of Pipeline Valves
10)	API RP1110	Recommended Practice for Pressure Testing of Liquid Petroleum Pipelines
11)	API RP1102	Recommended Practice for Liquid Petroleum Crossing Railroads and Highways
12)	API RP1109	Recommended Practice for Marking Petroleum Pipeline Facilities
13)	DOT Part 195	Minimum Federal Safety Standards for Liquid Pipelines
14)	PFI	Pipe Fubrication Institute

15)	API 1104	Standard for Welding Pipelines and Related Facilities
16)	ANSI B31.1	Power Piping
17)	ANSI B31.5	Refrigeration Piping
18)	ANSI A21.10	Cast Iron Fittings, 2 inch through 48 inch, for Water Other Liquid
19)	ANSI B16.1	Cast Iron Pipe Flanges and Flanged Fittings, 25, 125, 250, and 800 lb.
20)	ANSI B16.10	Face-to-Face and End-to-End Dimensions of Ferrous Valves
21)	ANSI B16.11	Forged Steel Fittings, Socket Welding and Threaded
22)	ANSI B16.34	Steel Buttwelding End Valves
23)	API 526	Flanged Steel Safety Relief Valves
24)	API 595	Cast-Iron Gate Valves, Flanged Ends
25)	API 599	Steel Plug Valves
26)	API 600	Steel Gate Valves, Flanged or Buttwelding End
27)	API 601	Metallic Gaskets for Refinery Piping, Double-Jaketed Corrugated and Spiral Work
28)	API 602	Small Carbon Steel Gate Valves, Compact Design
29)	API 604	Ductile Iron Gate Valves, Flanged Ends

30)	API 605	Large Diameter Carbon Steel Flanges (Size; 26 inch to 60 inch inclusive; Nominal Pressure Rating: 75, 150, and 300 lb.)
31)	API 609	Butterfly Valves, to 150 psig and 150 p
32)	MSS SP43	Wrought Stainless Steel Buttwelding Fittings
33)	MSS SP58	Pipe Hangers & Supports-Materials and Design
34)	ANSI B2.1	Pipe Threads (Except Dryseal)
35)	ANSI B16.20	Ring-Joint Gaskets and Grooves for Steel Pipe Flanges
36)	ANSI B16.21	Non-Matallic Gaskets for Pipe Flanges
37)	ANSI B16.25	Buttwelding Ends for Pipe, Valves, Flanges, and Fittings
38)	API 1105	Bulletin on Construction Practices for Oil and Products Pipelines
39)	API 2201	Welding or Hot Tapping on Equipment Containing Flammables
40)	ASME	Boiler and Pressure Vessel Code, Section VIII Pressure Vessels-Division1, Section VIII Alternate Rules for Pressure Vessels-Division2, and Section IX, Welding Qualifications
41)	NACE RP-01-69	Recommended Practice-Control of Extern Corrosion on Underground or Submerged Metallic Piping Systems
42)	NFPA 30	Flammable and Combustible Liquids Code

43)	JPI-7S-1-65	Steel Butt Welding Fittings for Special Piping Use
44)	JPI-7S-2-65	Steel Butt Welding Fittings for Ordinary Piping Use
45)	JPI-7S-3-65	Steel Socket Welding Fittings for Special Piping Use
46)	JPI-7S-4-71	Asbestos-Sheets for Petroleum Industry
47)	JPI-7S-14-61	Electric-Arc-Welded Carbon Steel Pipes for Petroleum Industry
48)	JPI-7S-15-70	Steel Pipe Flanges for The Petroleum Industry
49)	JPI-7S-16-72	Non-Metallic Gaskets Dimension for Petroleum Industry
50)	JPI-7S-18-62T	Mortar-Lining Steel Pipe for Ordinary Piping
51)	JPI-7S-23-72	Ring-Joint Gaskets and Grooves for Petroleum Industry
52)	JPI-7S-24-74	Standard Marking System for Valves
53)	JPI-7S-31-71	Welder Performance Qualification
54)	JPI-7S-36-75	Cast and Forged Steel Small Valves for the Petroleum Industry (Class 600, Threaded or Socket-Welding Ends)
55)	JPI-7S-37-65	Standard for Flanged Cast-Iron Outside Screw Gate Valves

56)	JPI-7S-39-74	Valve Inspection and Test
57)	JPI-7S-41-70	Spiral Wound Gaskets for Petroleum Industry
58)	JPI-7S-43-72	Large Diameter Carbon Steel Flanges fo Petroleum Industry
59)	JPI-7S-46-74	Cast Steel Flanged Valves for the Petroleum Industry (Class 150, 300)
60)	JPI-7S-47-74	Cast Steel Valves for the Petroleum Industry Flanged or Buttwelding Ends (Class 600 to 2500)
61)	JPI-7S-48-74	Flanged Ball Valves for the Petroleum Industry

1) ASHRAE — American Society of Heating, Refrigerating and Air-Conditioning Engineers

2) ANSI — American National Standard Institute

11 Safety Standards, Codes and Practices for Plant Design

1)	IP	The Institute of Petroleum
2)	NFPA	National Fire Protection Association
3)	OSHA	Occupational Safety and Health Administration

1)	ASTM	American Society for Testing and Materials
2)	JIS	Japanese Industrial Standards
3)	BS	British Standards Institution
4)	DIN	Deutscher Normenausschus

13 Analytical Methods for Waste Water

1) ASTM Standards Part 31 Water

2) WHO Standards for Drinking Water

1)	AISC	Design, Fabrication and Erection of Structural Steel for Building
2)	ASME	Pressure Vessel Section VIII Div. 1
3)	ANSI B31.3	Petroleum Refinery Piping
4)	ASTM	American Society for Testing and Materials
5)	API RP 530	Recommended Practice for Calculation of Heater Tube Thickness in Petroleum Refineries
6)	API Std 630	Tube and Header Dimensions for Fired Heaters for Refinery Services

15 Painting & Coating Standards

1)	NAPCA	National Association of Pipe Coating Applicators Specifications
2)	AWWA C203	Coal-tar protective Coatings and Lining for Steel Water Pipelines - Enamel and Tape - Hot - Applied
3)	SIS 05-5900	Pictorial Surface Preparation Standards for Painting Steel Surfaces
4)	SIS 18.51.11	European Scale of Degree of Rusting for Anticorrosive Paints
5)	MUNSELL	Munsell Book of Colour
6)	JIS	Japanese Industrial Standards
7)	SSPC	Steel Structures Painting Council
8)	ASTM	American Society for Testing and Materials
9)	BS	British Standards Institution
10)	NACE	National Association of Corrosion Engineers

16 Insulation Standards

1)	JIS	Japanese Industrial Standards
2)	ASTM	American Society for Testing and Materials
3)	TIMA	Thermal Insulation Manufactures Association
4)	MIL	Military Specification
5)	USAEC	United States Atomic Energy Commission Regulatory Guide 1. 36

17 Civil & Marine Standards

1)	AASHTO	American Association of State Highway and Transportation Officials
2)	ACI	American Concrete Institute
3)	AISC	American Institute of Steel Construction
4)	AWWA	American Water Works Association
5)	AWS	American Welding Society
6)	UBC	Uniform Building Code
7)	ASTM	American Society for Testing and Materials
8)	IMCO	Inter-Governmental Maritime Consultative Organization
9)	API	American Petroleum Institute
10)	AIJ	Architectural Institute of Japan
11)	JASS	Japanese Architectural Standard Specification
12)	CEIF	Civil Engineer Institute of Japan
13)	JPHA	Japan Port and Harbor Association

ANNEX III-4

[redacted] PROCESS SCHEME OF CONVENTIONAL ROUTE

ANNEX III-4

ALTERNATE PROCESS SCHEME OF CONVENTIONAL ROUTE

Besides the selected process scheme for the study, the following alternate schemes may be examined in the detail study in future.

(1) Elimination of the hydrofinishing unit

For quality of lube base oils, stability, color and sulfur content are important properties required. Instability and bad color are mainly due to existence of such impurities as sulfur/nitrogen/oxygen compound, etc. as well as aromatic and naphthenic hydrocarbons in base oils.

In the planned scheme of the study, the hydrofinishing unit is added to meet the specification of sulfur content (0.3 or 0.5 wt%) as well as to decolor and improve oxidation/color stability of base oils.

Among the conventional routes, there are two major trends in the world. One is American and Japanese way which provides a hydrofinishing unit aiming at the above mentioned objectives and the other is an European way being adopted mainly by SHELL which has no such unit although in the latter case the sulfur content cannot be reduced as low as 0.3 - 0.5 wt%. In non-existing case of the hydrofinishing unit, they have to cut each distillate in very narrow boiling range, so that the vacuum distillation unit should become more sophisticated as described below, comparing with the conventional route.

- Larger number of trays (two towers)
- Higher vacuum level (lower pressure)
- More side cuts (swing cut is normally drawn off between each distillate)

This is because the narrow cut distillation are required to improve selectivity of removing aromatics and other impurities as extract in the following solvent extraction unit. Nevertheless the operating conditions of the solvent extraction unit should become more severe than the case of providing the hydrofinishing unit.

The choice, whether it adopts hydrofinishing or not, mainly depends upon the policy of process owner or refiner in terms of product quality, especially sulfur content and stability. Regarding stability of the base oil to be used for automotive oil, it can be improved by special additives, while industrial oils such as turbine oil, etc., still require hydrotreatment.

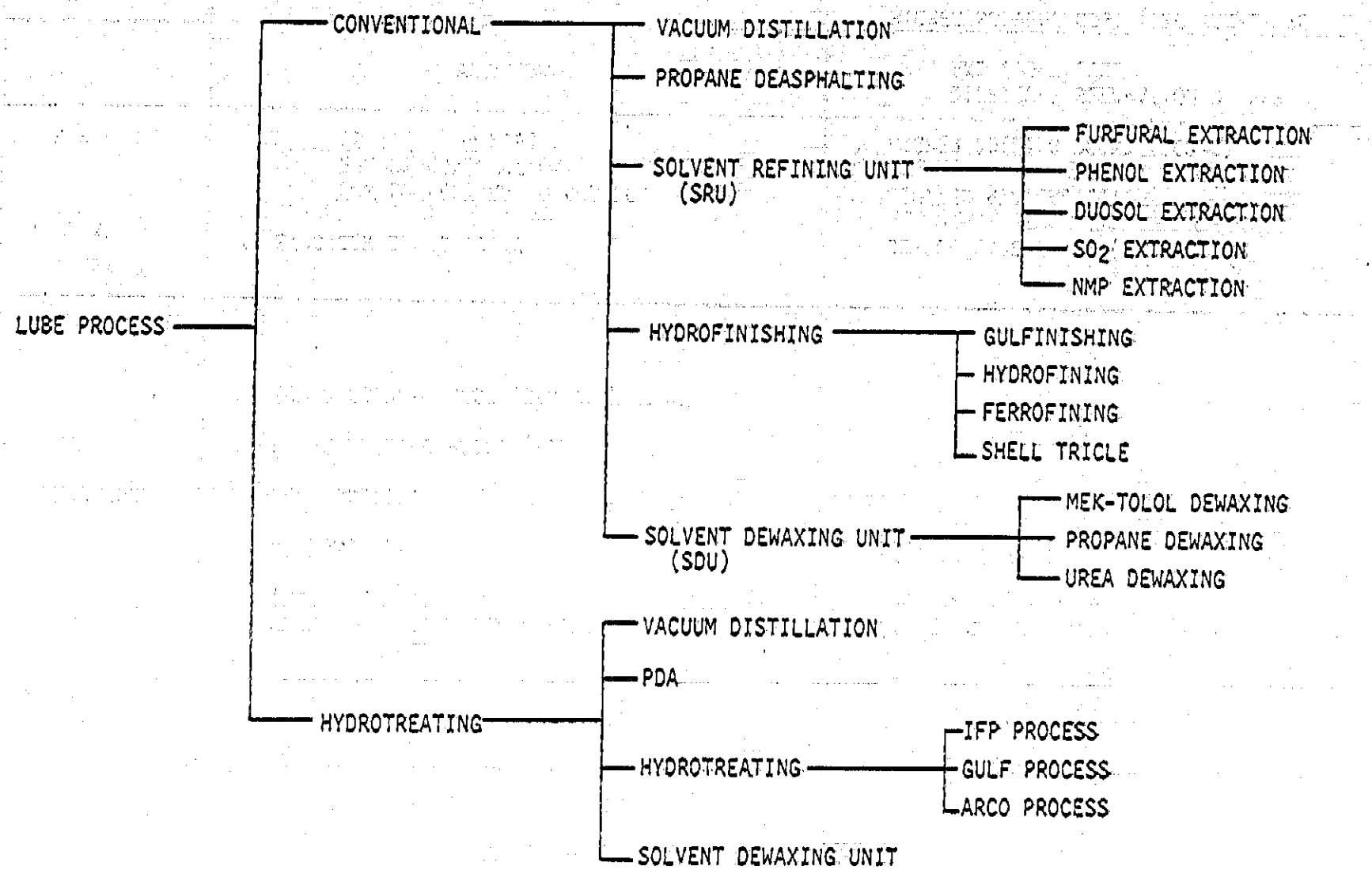
(2) Substitute processes

In the planned scheme, furfural process for the solvent extraction and MEK process for the dewaxing are selected respectively. Instead of these processes, the following processes could be selected as substitutes.

- NMP extraction instead of furfural
- Catalytic dewaxing instead of MEK

Although these substitute processes have merits and demerits against the selected processes, the furfural extraction and MEK dewaxing process are eventually selected for this study as typical process suitable for the Thai lube base oil plant after assesment of various aspects in Thailand in terms of lube oil specification, demand forecast, availability of chemicals etc.

SUMMARY OF LUBE PROCESS



COMPARISON OF SOLVENT REFINING UNIT

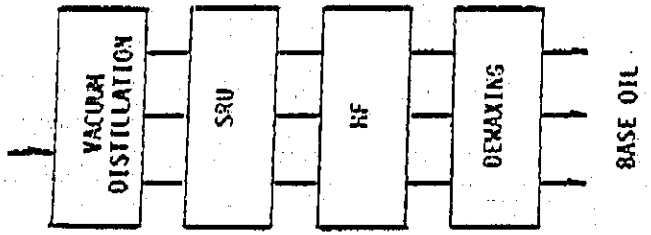
	ADVANTAGE	DISADVANTAGE
FURFURAL	° MUCH COMMERCIAL EXPERIENCES (MORE THAN 100) ° AVAILABILITY ° LOW TOXICITY ° LOWER BOILING POINT (162°C) ° LOWER SOLVENT COST (360 YEN/LITRE)	° HIGHER SOLVENT RATIO THAN NMP (1.5 ~ 3.5)
N M P	° STRONGER SELECTIVITY LOW SOLVENT RATIO AND LOW ENERGY CONSUMPTION (S.R. ~ 2.5)	° SCARCE EXPERIENCE (3 UNITS) ° LIMITED AVAILABILITY ° HIGHER BOILING POINT (202°C) DIFFICULT SEPARATION OF NMP AND LIGHT LUBE ° HIGHER SOLVENT COST (720 YEN/LITRE)

COMPARISON OF DEWAXING UNIT

	ADVANTAGE	DISADVANTAGE
SOLVENT DEWAXING	◦ MUCH EXPERIENCES ◦ HIGHER VISCOSITY INDEX	◦ HIGHER INVESTMENT ◦ SOPHISTICATED OPERATION REQUIRED
CATALYTIC DEWAXING (MOBIL & BP)	◦ LOWER COST 1) INVESTMENT 2) OPERATING ◦ HIGHER 1) YIELD 2) BY-PRODUCT VALUE ◦ LESS PLOT AREA	◦ LESS EXPERIENCE ◦ LOWER VISCOSITY INDEX (5 ~ 11 FOR NEUTRAL OIL AND 2 FOR BRIGHT STOCK)

COMPARISON WITH AND WITHOUT HYDROFINISHING

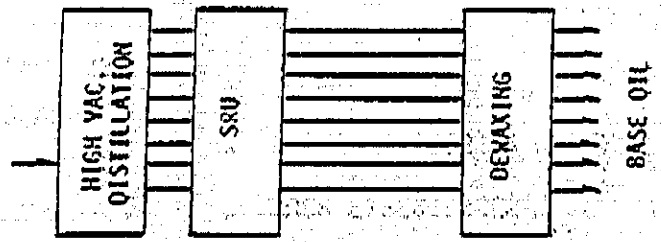
WITH HF



. 20 ~ 30 TRAYS

1) LOW SULFUR (APPLICABLE FOR INDUSTRIAL LUBE TOO)
2) LOWER INVESTMENT (4 BILLION YEN FOR VDU AND HF UNITS)
3) HIGHER FLEXIBILITY AND OPERABILITY
4) MARGINAL RAISE OF VI BY HF

WITHOUT HF



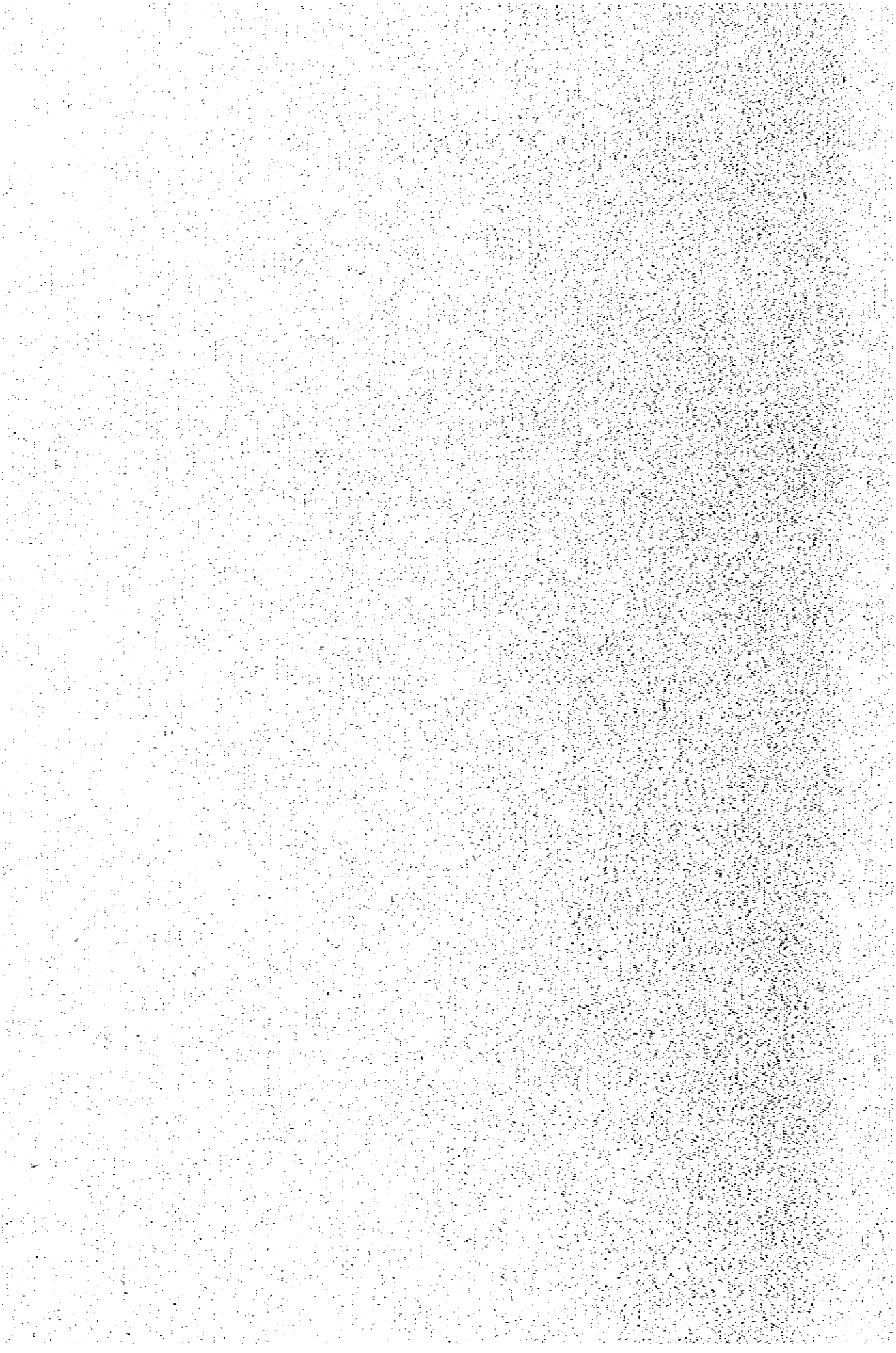
. SOPHISTICATED VDU (2 COLUMNS WITH 100 TRAYS)

1) HIGHER SULFUR (NOT APPLICABLE FOR INDUSTRIAL LUBE)
2) MUCH MOTIVE STEAM FOR VDU IS REQUIRED.
3) HIGHER INVESTMENT FOR VDU (FIVE BILLION YEN FOR TWO COLUMNS PROVIDED WITH 100 TRAYS)
4) MANY INTERMEDIATES TANKS ARE REQUIRED.
5) SOPHISTICATED OPERATION FOR VDU AND SRU

ANNEX IV

ANNEX IV-1

MAXIMIZATION OF THAI LOCAL CONTENTS



ANNEX IV-1

MAXIMIZATION OF THAI LOCAL CONTENTS

As a general philosophy taken in this study, maximization of the local contents for the project is intended to contribute for Thai economy, otherwise to spend considerable amount of foreign currencies as such. As shown in Table IV-2 the percentage of the local currency to the total plant cost excluding import taxes, etc. will be in a range of 25 - 30%.

In order to maximize local currency portion of the cost estimates the following items are taken into consideration as far as it will be practical and economical to the project at the time of 1988.

(1) Equipment and Materials

a) Some equipment and machinery such as carbon steel low pressure vessels and light duty pumps will be purchased in consideration of cost, schedule and import duty when imported.

b) Major bulk materials will be supplied from Thai suppliers.

These items include the following:

- civil materials such as cement, brick, stone, sand, concrete piles, reinforced steel bars, concrete sewer pipes, etc.
- building materials including air conditioning equipment and plumbing
- small steel shapes
- cables and wires
- lighting fixtures

- small capacity transformers
- refractory and castables
- painting and insulation materials, etc.

(2) Field Construction

a) All of construction work will be divided into a number of categories and groups each to be subcontracted to Thai subcontractors.

The subcontracting items include:

- field fabricated storage tanks
- field prefabrication of pipes
- equipment erection
- civil and building work divided into many categories
- piping, electrical, instrument work
- painting, insulation, castable work, etc.

In this regard expatriate skilled labor is minimized in this project, that is all kind of laborers and construction supervisors will be Thai nationals.

(3) Temporary Facilities and Construction Equipment

Materials and laborers for temporary facilities will be mostly supplied by Thai constructors. Only small number of machinery will be imported for the temporary facilities. It is assumed in this study that large construction equipment; e.g. mobile cranes larger than 100 ton will be brought into Thailand and maintained by the prime contractor's construction contingent to supply some small subcontractors.

(4) Chemicals and Others

As much materials and services as possible are considered to be supplied in Thailand, they includes:

- Usual chemicals for the initial fills except such special chemicals as furfural and MEK.

- Indirect laborers necessary for construction such as for operation of field office, warehousing, camp keeping, etc.

- Inland transportation, etc.