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PETROVIETNAM
PRE-INVESTMENT STUDY

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1. OIL AND THE REFINING INDUSTRY IN THE WORLD

1. The oil industry in recent years
2. Crude oil availability
3. Petroleum product consumption
4. The refining industry
5. Transport

This Chapter sets out to review recent events affecting the oil industry and to present an up-to-date picture of its various aspects.

It is evident that the oil industry cannot be developed in VIETNAM independently of the international situation, particularly if VIETNAM is to become an oil-production country.

1. THE OIL INDUSTRY IN RECENT YEARS

Oil has since the end of the Second World War gradually become the most important source of energy for the majority of countries (see Figure 1.1).

This development was encouraged by ever-decreasing prices (in constant currency) until 1971 (see table 1.1).

Low energy costs represented one of the main factors responsible for rapid economic growth in the industrialized countries ; demand for petroleum products was currently growing at a rate of about 10 % in most of the major consumer countries.

Crude oil production increased over this period in proportion to the growing consumption.

In 1971 crude oil prices began to rise as a result of pressure from certain producing countries, but it was not till late 1973 that prices suddenly quadrupled as a consequence of the Middle East crisis (see table 1.1). This sharp rise was responsible for considerable upheavals in many areas and its effects are still strongly felt today.

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	FIGURE 1.1.	3.	belcip DEI

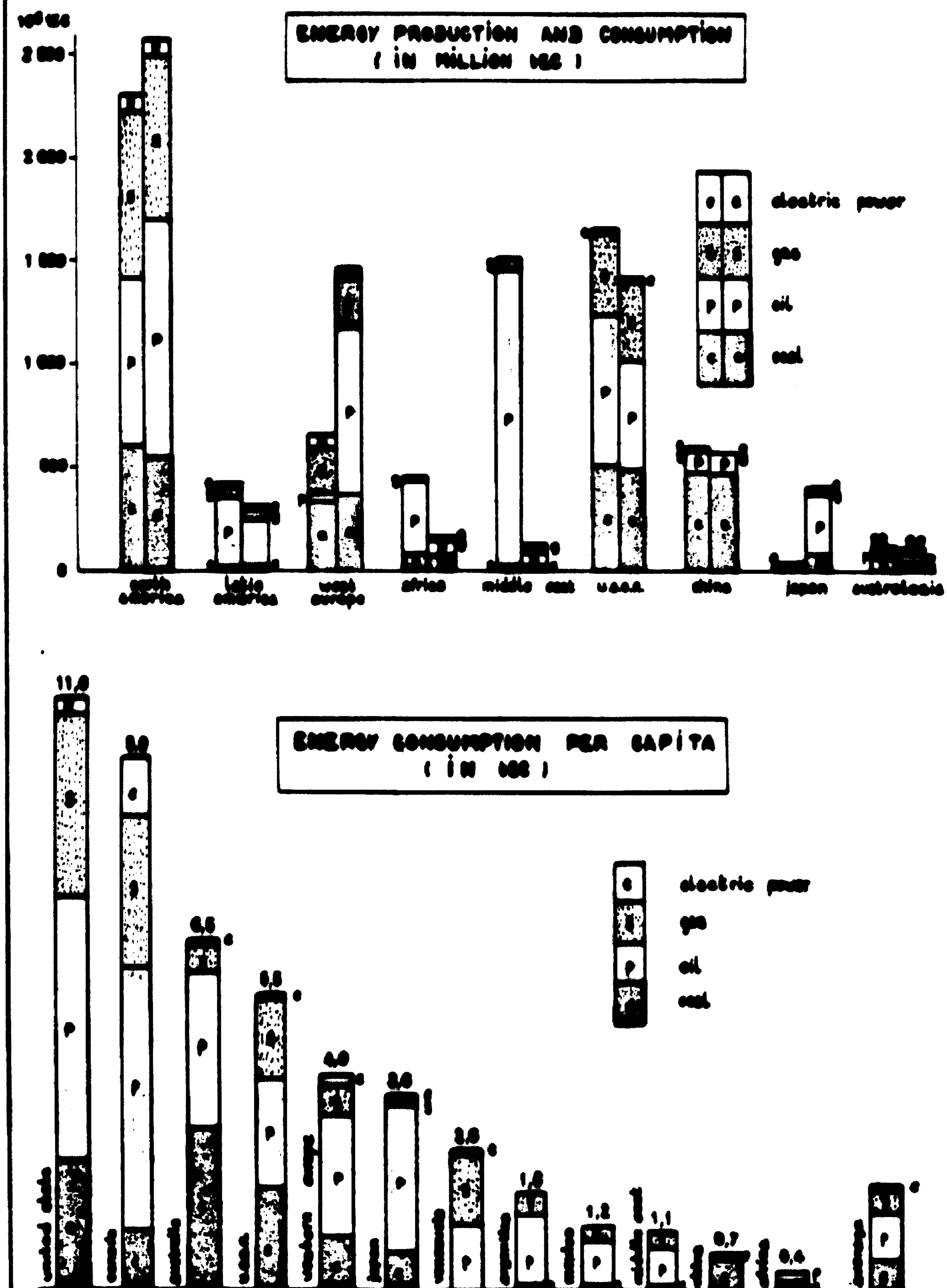

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TABLE 1.1

EVOLUTION OF POSTED PRICE OF TYPICAL CRUDE OILS

(US$/BARREL)

YEARS	ARABIAN LIGHT 34°API	KUWAIT 31°API
1948	2.22	2.12
1949	1.75	1.65
1953	1.97	1.72
1957	2.12	1.86
1959	1.94	1.67
1960	1.84	1.59
1971	1.80	1.68
1972	2.28	2.19
1973(jan)	2.59	2.48
1974(sept)	11.65	11.55
1975	11.25	11.15
1978	12.70	12.22

2. CRUDE OIL RESERVES

World crude oil production has increased tenfold since the end of the Second World War and threefold since 1960 (see table 1.2). This might be taken as indicating unlimited supplies of crude oil.

The fact is, however, that at present production rates known reserves of crude oil will be practically exhausted by the beginning of the next century (see table1.3). Although new fields may still be to be discovered, it seems that the importance of oil as a source of energy is likely to decline swiftly at the end of this century.

Recent years have seen Middle East production continuing to grow while that of the United States falls off (see table 1.4). As a result the major consumers (with the exception of the communist countries) have become heavily dependent on imported oil (see table 1.5).

PRICES

Since the 1973/1974 increases crude oil prices have not risen in keeping with world inflation rates.

The current price scale is based on the "marker crude" price - ARABIAN LIGHT - and on the crude oil grade (°API, sulphur content) as well as on the distance between supplier and consumer. Note that the credit period is now also taken into account in the price (see table 1.6).

Since 1974 the official prices have closely matched actual selling prices ; discounts when allowed are small and generally apply only to crude oils that are difficult to sell.

TABLE 1.2

WORLD CRUDE OIL PRODUCTION

(THOUSAND TONS)

YEARS	TOTAL
1930	196 500
1945	353 000
1950	525 000
1960	1 090 000
1965	1 504 000
1970	2 335 000
1973	2 845 000
1977	3 019 000

TABLE 1.3

WORLD CRUDE OIL RESERVES - 1978

REGIONS	Million tons	%	Production years (basis 1977)
NORTH AMERICA	4 800	5.5	9.0
SOUTH AMERICA	5 500	6.2	24.0
MIDDLE EAST	50 300	57.1	48.0
FAR EAST	2 700	3.1	20.0
AFRICA	7 700	8.8	27.0
WESTERN EUROPE	3 700	4.1	55.0
SOCIALIST COUNTRIES	13 400	15.2	20.0
T O T A L	88 100	100.0	29.0

TABLE 1.4

CRUDE OIL PRODUCTION BY COUNTRY

(1977)

COUNTRIES	THOUSAND TONS	%
NORTH AMERICA	**533 300**	**17.7**
UNITED STATES	462 800	15.3
CANADA	70 500	2.4
SOUTH AMERICA	**232 800**	**7.7**
VENEZUELA	116 500	3.9
MEXICO	51 700	1.7
MIDDLE EAST	**1 104 900**	**36.6**
SAUDI ARABIA	453 200	15.0
KUWAIT	94 300	3.1
IRAK	111 000	3.7
IRAN	276 400	9.1
ABU DHABI	79 700	2.6
AFRICA	**284 300**	**9.4**
NIGERIA	104 300	3.4
LIBYA	100 100	3.3
ALGERIA	53 500	1.8
WESTERN EUROPE	**64 100**	**2.2**
UNITED KINGDOM	37 500	1.2
FAR EAST ASIA	**134 900**	**4.4**
INDONESIA	83 200	2.8
EASTERN EUROPE	**566 700**	**18.9**
USSR	546 000	18.1
CHINA	**94 000**	**3.1**
TOTAL	**3 018 000**	**100.0**

TABLE 1.5

CRUDE OIL IMPORTS (1976)

TO \ FROM	MIDDLE EAST	AFRICA	OTHERS	TOTAL IMPORTS	TOTAL PRODUCTION
UNITED STATES	113 000	106 500	77 700	297 200	400 000*
WESTERN EUROPE	462 700	119 000	49 400	631 100	39 100
JAPAN	172 900	2 000	54 900	229 800	000

* Including condensate

TABLE 1.6

PRICES OF KEY OPEC CRUDE OILS

CRUDE OIL	GRAVITY ° API	OFFICIAL SELLING PRICE - July 78	DAYS CREDIT	AVERAGE SUPPLY 1978 - '000BSD
ARABIAN LIGHT	34	12.70	60	5 000
ARABIAN HEAVY	27	12.01	60	2 750
IRANIAN LIGHT	34	12.81	60	2 900
IRANIAN HEAVY	31	12.49	60	2 500
KUWAIT	31	12.22	60	2 000
ABU DHABI (MURBAN)	38	13.26	60	850
IRAQ, BASRAH LIGHT	34	12.60	60-75	600
IRAQ, KIRKUK (1)	36	12.82	60-75	300
IRAQ, KIRKUK (2)	35.3	13.10	45	300
ALGERIAN SAHARAN	44	14.10	30	890
NIGERIA BONNY LIGHT	37	13.87	60	525
LIBYA ES SIDER	37	13.88	60	710
NORTH SEA EKOFISK	40	13.82	30	380
INDONESIA MINAS	35	13.55	30	800
VENEZUELA LAGO MEDIO	32	13.84	30	530

(1) *GULF terminal*

(2) *Med. terminal*

3. PETROLEUM PRODUCT CONSUMPTION

Between 1960 and 1973 world petroleum product consumption grew at an average rate of 8 % per year ; note that this is the average of widely varying figures :

- UNITED STATES + 4.7 %/year
- WESTERN EUROPE + 10.5 %/year
- JAPAN + 18.0 %/year
- U.S.S.R. + 8.4 %/year

These give an indication of the effects of the 1973/1974 oil price increases on the economies of JAPAN and WESTERN EUROPE.

The situation since 1974 is that consumption in WESTERN EUROPE and JAPAN has not returned to the 1973 level, while in the UNITED STATES the growth rate was less than 2 %/year between 1973 and 1977 (see table 1.7).

DEMAND STRUCTURE

The petroleum product demand structure varies greatly from one country to another (see table 1.8). Since 1974 another change has been taking place, with increased demand for light products such as gasolines and naphtha accompanied by a drop in demand for heavier products such as fuel oil which faces competition from coal and nuclear power.

This will inevitably have its repercussions on crude oil prices, to the advantage of the lighter crudes, and on end product prices.

PRODUCT PRICES

A distinction must be drawn between domestic prices (ex-refinery and retail prices) and international prices.

Each country has its own domestic price structure. Ex-refinery prices, for example, are generally calculated to allow the refiner to cover crude oil and refining costs. Taking FRANCE as an example, official ex-refinery prices in May 1978 were as follows :

	F/hl
Regular gasoline	63.39
Super	70.09
Gas oil	51.42
Heavy fuel oil	412 F/ton

Although structures may vary from country to country they are more or less based on a generally recognized international standard.

International trade takes many different forms. Trading may be carried on between companies or States under terms which are not generally publicised, and on the other hand there exists a number of established markets publishing their official prices, e.g. ROTTERDAM, ITALY, SINGAPORE.

While quantities traded are small, the prices quoted are often taken as a guide in inter-company transactions and in some cases in determining domestic price structures.

Posted prices in the major export centres can be found in table 1.9. These prices do not include the normal refinery profit margin but correspond simply to the crude oil price plus direct operating costs.

Such prices are subject to considerable fluctuation over a year ; sometimes periodically, e.g. summer/winter variations, and sometimes also unexpectedly e.g. wide variations in time of crisis.

Whatever their exact significance these prices reflect the major market movements. At the moment, for instance, residual fuel oil prices on the export market are tending to fall as a result of low demand levels and particularly of heavy product surpluses created by many refineries being unmatched to there markets. Export prices are of course also determined by product grade, notably in the case of fuel oils the prices of which are affected by their sulphur content and to a lesser extent their pour point. Thus on the SINGAPORE market for example 3.5 % sulphur fuel oil fetches 72$/ton as against 90$/ton for low sulphur residue.

TABLE 1.7

PETROLEUM PRODUCT CONSUMPTION* (1975)

COUNTRY	%	Million tons	kg per capita
NORTH AMERICA	**32.2**	**737.2**	**3 116**
UNITED STATES	29.1	664.6	3 111
SOUTH AMERICA	**6.4**	**146.9**	**400**
WESTERN EUROPE	**23.0**	**526.1**	**1 442**
WESTERN GERMANY	4.7	107.7	1 741
FRANCE	3.8	87.5	1 652
UNITED KINGDOM	3.3	75.7	1 340
MIDDLE EAST	**2.2**	**50.9**	**404**
AFRICA	**2.0**	**44.8**	**112**
FAR EAST ASIA	**12.0**	**274.2**	**222**
JAPAN	8.4	192.9	1 738
SOCIALIST COUNTRIES	**20.8**	**474.6**	**-**
U.S.S.R	14.8	337.2	1 325
Others	**1.4**	**30.9**	**-**
T O T A L	**100.0**	**2 284.5**	**500**

**** Approximated figures***

TABLE 1.8

DEMAND PATTERN (1976)

COUNTRIES	MOTOR GASOLINE wt %	KERO + GAS OIL wt %	FUEL OIL wt %	OTHERS (1) wt %
UNITED STATES	40	25	15	17
WESTERN GERMANY	18	47	18	13
FRANCE	17	37	28	14
UNITED KINGDOM	21	28	30	13
BRAZIL	28	28	29	14
INDIA	8	50	20	18
JAPAN	11	24	41	19
PHILIPPINES	24	30	34	7
INDONESIA	23	45	15	13
VIETNAM (1977)	22	48	23	8

(1) *Including naphtha, asphalt, lubricants, etc.. but excluding losses and refinery fuel*

TABLE 1.9

PETROLEUM PRODUCT SPOT PRICES (US$/TON)

(JULY 1978)

	ROTTERDAM	ITALY	SINGAPORE	ARABIAN/PERSIAN GULF
NAPHTHA	138	133	130	125
PREMIUM GASOLINE	158	151	160	157
REGULAR GASOLINE	143	134	155	148
JET KEROSENE	135	131	136	138
GAS OIL	121	121	123	121
FUEL OIL 3.5 % S	74	72	72	66
FUEL OIL 1.0 % S	80	77	-	-

4. THE REFINING INDUSTRY

Until 1973 the refining industry in the major consumer countries matched demand trends ; thus in that year the European refinery construction rate was 12-14 %/year, while in the UNITED STATES refining capacity was expanding at only 3 to 4 % annually.

The 1973/1974 crisis and its consequences on consumption created substantial over-capacity, particularly in EUROPE, as construction programmes already under way could not be abruptly halted.

The present European capacity utilisation rate is no higher than 64 %, compared to 83% in JAPAN and 92 % in the UNITED STATES (see table1.10).

Refiners are being obliged to modify their production schemes to match the changing demand structure and notably to set up heavy product conversion units and also desulphurisation units in order to comply with increasingly strict sulphur specifications.

TABLE 1.10

REFINING CAPACITIES

(1 JAN.1977)

COUNTRY	THOUSAND TONS/YEAR
NORTH AMERICA	**904 700**
UNITED STATES	808 500
SOUTH AMERICA	**306 000**
VENEZUELA	75 800
BRAZIL	48 900
MEXICO	45 100
NETHERLANDS ANTILLES	40 900
WESTERN EUROPE	**1 016 700**
ITALY	213 200
FRANCE	165 200
WEST GERMANY	154 000
UNITED KINGDOM	150 000
MIDDLE EAST	**183 900**
IRAN	31 100
KUWAIT	30 100
SAUDI ARABIA	22 700
AFRICA	**75 400**
FAR EAST ASIA	**400 300**
JAPAN	276 200
SINGAPORE	45 800
SOCIALIST COUNTRIES	**[illegible]**
U S S R	460 000
T O T A L	**3 076 800**

5. TRANSPORT

As the major consumers - with the exception of the USSR - are unable to meet their own requirements, substantial amounts of crude oil have to be imported. WESTERN EUROPE and JAPAN are particularly dependent on imports, but so also to some extent are all the world's non oil producing countries.

Tanker fleets, like refining capacity, were expanded to match demand growth up to 1973. The volume of shipbuilding contracts already awarded at that point was such that the resulting surplus capacity will not be fully utilised for some time to come.

Thus at the beginning of 1978 the oil tanker fleet represented 332.5 Million DWT, with a gross tanker surplus of over 100 million DWT.

This has let do shipowners - apart from oil companies and Stat-owned fleets - operating at extremely low transport costs.

Transport costs are generally expressed in terms of the Worldscale Index (WS), which corresponds to 20,000 DWT vessels.

The AFRA (Average Freight Rate Assessment) rate quoted in specialist publications gives an average crude transport cost at any one moment and by tanker size, expressed as a percentage of Worldscale. Current rates are shown in table 1.11 . Present spot prices on GULF/EUROPE routes are very low indeed - WS 35 in the case of VLCC (tankers of over 160,000 DWT) as opposed to WS 44.5 for AFRA.

Thus transport costs which in 1970 accounted for almost 50 % of the CIF EUROPE price of PERSIAN GULF crude now represent only some 3 to 4 % of CIF price on the same route.

In 1967 closure of the SUEZ CANAL led to a major increase in tanker size, the largest now being around 500,000 DWT.

The volume of end product transport is much smaller and distances are generally short - East to West Coast in the UNITED STATES, island to island in JAPAN, for example. Vessels used are of 20 to 30,000 DWT size.

TABLE 1.11

AFRA QUOTATION - APRIL 1978

	in WS 1978
GENERAL PURPOSE 10000 - 24999 DWT	152.0
MEDIUM RANGE 25000 - 44999 DWT	112.0
LARGE RANGE 1 45000 - 79999 DWT	80.4
LARGE RANGE 2 80000 - 159999 DWT	61.3
VLCC 160000 - 319999 DWT	44.0

2. THE PETROLEUM PRODUCTS MATKET IN VIETNAM MEETING FUTURE REQUIREMENTS

1. Petroleum product consumption
2. Crude oil supplies

INTRODUCTION

Present petroleum product consumption figures (in tons) for VIETNAM are as follows :

LPG	20 000
Gasolines	500 000
Kerosene	250 000
Jet fuel	70 000
Diesel oil	710 000
Fuel oil	520 000
Asphalt	80 000
Lube oils	75 000
TOTAL	2 225 000

The total lack of past consumption statistics for the country as a whole combines with the troubled state of the country in recent years to make any study of future consumption trends very difficult. In this situation none of the classic consumption forecasting methods can be applied : statistical and econometric methods depend upon analysis of sets of past consumption figures, either overall or for each of the main products; analytical methods require in-depth knowledge of the major consuming sectors and their likely development, e.g. the vehicle population (in relation to gasoline consumption) or the development of electric power generation (in the case of fuel oil used in power stations) ; comparative methods attempt to describe future development on the basis of trends in other, economically stronger countries, and there are very few suitable models for comparison with perhaps the exception of growth in some European countries after the Second World War.

This study of the Vietnamese petroleum products market will therefore be based on a general macroeconomic approach, which can only be approximative ; results obtained should be considered as orders of magniture, in view of the large number of hypotheses selected.

To the uncertainties as to petroleum product consumption development are added those in the matter of crude oil supplies.

While local production prospects appear good, it is not possible at this stage to get an exact idea as to quantities, grades or when the various potential oil fields will start to be worked. Use of imported crudes seems more or less inevitable, particularly since first findings as to future Vietnamese crude oil quality indicate that it is likely to be unsuited to the domestic market but would on the other hand -under certain conditions- be readily exportable to major consuming countries.

1. PETROLEUM PRODUCT CONSUMPTION

1.1. ENERGY PRODUCTS

1.1.1. OVERALL ESTIMATE

Any evaluation of the data supplied by PETROVIETNAM -which in fact represent planning objectives- has to be based on domestic energy consumption.

a) According to BEICIP's information, present energy consumption in VIETNAM can be gauged at some 7.5 million tons coal equivalent, broken down as follows :

		MM TCE
Electricity (hydro-electricity)	500,000,000 kWh	0.12
Coal		4.00
Oil	2,225,000 tons	3.30
		7.50

Total coal production is estimated at about 5 million tons, of which 1 million are exported -principally to JAPAN.

Assuming the following correlation :

1 ton oil equivalent = 1.5 ton coal equivalent,

present consumption is in the order of 105 kg OE per capita.

b) A comparison was made with other countries in the region. On the assumption (generally confirmed) that energy consumption per capita can be linked to per capita income, there appears a range within which the 1980 energy consumption level in VIETNAM can be estimated, taking income to be 200 US$/capita.

The table and graph which follow give an energy consumption level of about 150 kg/capita in VIETNAM, considering that the demand/income elasticity trend more or less reflects that of neighbouring countries, and the Vietnamese GDP can be estimated only by default.

Such a method can give only an approximate demand level.

On the basis of 150 kg/capita by 1980, total energy consumption amounts to :

7.7 million TOE
or 11.6 million TCE

broken down as follows :

Electricity	0.1 million TCE
Coal	6.0
Oil	5.5

Assuming coal production to be some 8 million tons with 2 million of this being exported, petroleum product consumption can thus be estimated at 5 to 6 million TCE, i.e. 3.3 to 4 million TOE.

These figures are consistent with the objectives of the 1976-1980 plan, under which 4.2 million tons total products and 3.9 million tons of energy products (excluding lube oils and asphalts) are forecast.

c) Plan objectives for 1985 seem too optimistic. They would correspond to an average rate of growth of 18 % per annum. This objective seems difficult to meet considering various factors likely to moderate the country's petroleum product consumption, among them :

- The refining sector will not be developed before 1983/1984 at the earliest.
- The distribution network is at present inadequate for fast consumption development and huge investments have to be made to improve means of transport and storage capacities for finished products.

- Local requirements will be satisfied by imports up to 1983/1984 and this is not an incentive for accelerating consumption growth.

d) For the purpose of the study, future trends in overall petroleum energy product consumption will be kept between two limits defined as follows :

- an upper limit which on the basis of the 1977 market (2,070,000 t) and the "upper" value of the 1980 market (4,000,000 t) will lead to a future estimate based on a 15 % annual growth rate (this is high compared to growth in neighbouring countries) ;

- and a lower limit which on the 1977 market and the "lower" value of the 1980 market (3,300,000 t) will lead to a future estimate based on a 10 % annual growth rate (the average growth rate in neighbouring countries would be about 10 to 12 %).

Keeping in mind the previous considerations on the development of petroleum activities in VIETNAM, the lower figures appear the most realistic.

	1977	1980	1985
Energy products consumption (in tons)	2,070,000	3,300,000	5,300,000
		4,000,000	8,000,000

TABLE 2.1

ENERGY CONSUMPTION

	(KG OE) 1974	1977	Petroleum products share-1974
VIETNAM		105	45
THAILAND	200	230	98
INDONESIA	80	100	95
MALAYSIA	310		98
PAKISTAN	130		37
INDIA	135		24
BURMA	37		91
BANGLADESH	20		35
PHILIPPINES	230	250	95
CHINA	430		
SRI LANKA	94		94

Domestic consumption including bunkers. Internal consumption in refineries and fields excluded. .

1,000 kWh = 0.123 TCE

1 TOE = 1.5 TCE

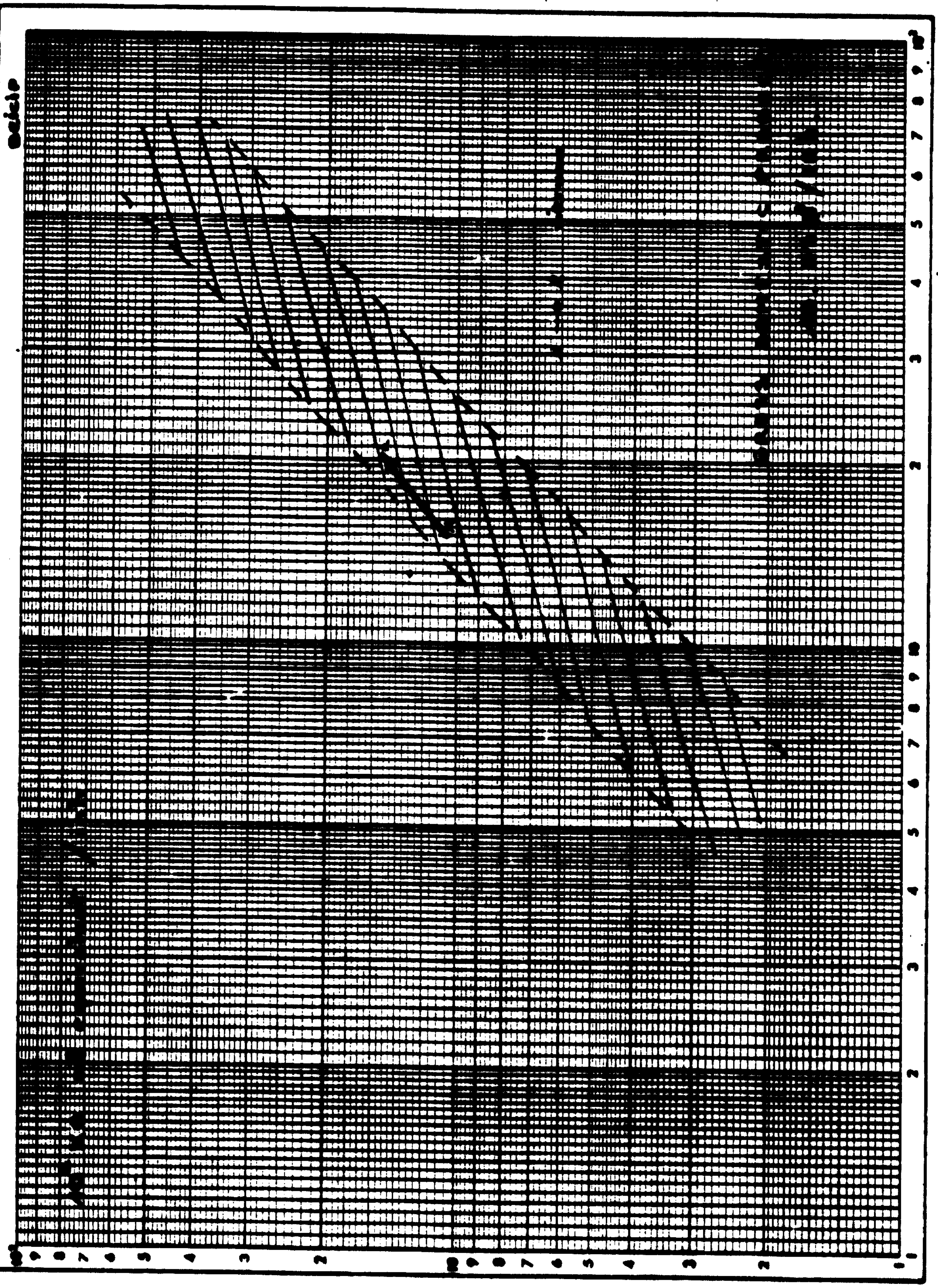


FIGURE 2.1

1.1.2. ESTIMATED DEMAND STRUCTURE

Table 2.2 shows, alongside Plan objectives for 1980 and 1985, BEICIP's consumption estimates for the main petroleum products.

The lack of any data on the major consumer sectors means that these estimates cannot be properly backed up ; they are based on developments in neighbouring or more or less comparable countries and should be viewed as only preliminary.

- *LPG*

  Present consumption is low and will probably be slow to grow until local production gets under way. The following tonnages may be assumed :

  35,000 tons in 1980
  and 70,000 tons by 1985.

- *Gasolines*

  In view of foreseeable vehicle population growth the 1980 Plan target, though on the optimistic side, seems reasonable. There is nothing, however, to support the 1985 figure ; an 8 % growth rate will be assumed for the 1980-1985 period.

- *Kerosene*

  The 1980 Plan figure seems slightly optimistic, although development of this domestic product is governed mainly by State pricing policy. The 1980-1985 growth rate will be taken as 10 %.

- *Jet fuel*

  On account of the gradual renewal of external air links and the building up of internal services, a 20 % growth rate will be assumed up to 1980 followed by 12 % from 1980 to 1985 - much higher than present growth rates in most other countries.

- ***Diesel oil***

  Diesel oil demand growth from now on is very hard to assess since it reflects the country's economic development. Up to 1980 swift growth will be assumed, taking into account the rebuilding programme and the present low level ; after that date a rate of about 10 % can be expected.

- ***Fuel oil***

  Fuel oil consumption will of course depend on the energy policy pursued prior to the refinery start-up. For instance, increased coal production could greatly reduce the need for foreign currency costly imports. Growth rates will be taken as similar to those for diesel oil.

TABLE 2.2.

ESTIMATED DEMAND STRUCTURE

PRODUCTS	PRESENT CONSUMPTION	1980		1985	
		PLAN	BEICIP	PLAN	BEICIP
L P G	20 000	50 000	35 000	108 000	70 000
GASOLINES	500 000	650 000	600 000	1 320 000	870 000
KEROSENE	250 000	400 000	345 000	918 000	550 000
JET FUEL	70 000	180 000	120 000	367 000	210 000
DIESEL OIL	710 000	1 500 000	1 300 000	3 600 000	2 100 000
FUEL OIL	520 000	1 150 000	900 000	2 700 000	1 500 000
T O T A L	2 070 000	3 910 000	3 300 000	9 712 000	5 300 000

1.2. NON-ENERGY PRODUCTS

a) LUBE OIL CONSUMPTION

Lube oil demand and demand growth can be compared to motor fuel demand. Analysis of the 1977 figures reveals the following breakdown :

Gasoline consumption	500,000 t or	675,000m³
Diesel oil consumption	710,000 t or	845,000m³
Combined gasoline + diesel oil consumption		1,520,000m³
Lube oil consumption	75,000 t or	83,000m³
Engine oil consumption (60 %)		50,000m³

This gives 3.3 l of engine oil for every 100 l of fuel. This is a high ratio, particularly since diesel is taken as being entirely engine fuel, and characteristic of an elderly vehicle population with a high proportion of trucks to light vehicles.

This figure can be compared to those obtained elsewhere :

NIGERIA	2.3
MOROCCO	1.9
FRANCE	1.5 (see figures 1 and 2).

In view of the objectives for 1985, not only do gasoline + gas oil consumption forecasts seem too high but lube oil forecasts even more so.

With the 1985 objectives the following figures are obtained :

Gasoline	1,320,000 tons or	1,785,000m³
Diesel oil	3,600,000 tons or	4,285,000m³
TOTAL		6,070,000m³
Lube oils	321,000 tons or	360,000m³
Engine oils (60 %)		215,000m³

i.e. in 1/100 l : 3.5

On the basis of annual demand for gasoline and diesel together being no higher, in 1985, than 3,500,000 tons or 4,300,000 m³ and the engine oil consumption ratio, in 1/100 l, being at most about 2.5, maximum demand for engine oil would be 110,000m³ or, when converted into lube oils, 165 000 tons or 183 000m³, assuming that the share represented by engine oils remains around 60 % of the total.

Starting from an average estimate of 3 000 000 tons for gasoline and diesel oil, corresponding lube oil consumption would reach about 150 000 tons or 167 000m³.

b) *ASPHALT CONSUMPTION*

Demand for asphalt should also be assessed in the light of potential requirements, mainly for road maintenance and modernisation. Given the lack of detailed information an initial estimate will be made on the basis of standard road requirements.

Maintenance	2.5 tons of asphalt per km
Resurfacing	15.0 tons of asphalt per km
Construction	30.0 tons of asphalt per km.

Taking the total roadway suitable for motor vehicles to be some 40 000 km, of which 15 000 km are asphalted, present requirements would thus be :

Maintenance	15 000 × 2.5	= 37,500
Resurfacing (10%)	1 500 × 15	= 22,500
Construction	500 × 30	= 15,000
giving a total of		75,000 tons

This is consistent with the 1977 figures (80,000 tons) taking into account other uses for asphalts.

Requirements by 1980 may be estimated, on the basis of 18,000 km of asphalted roadway, thus :

Maintenance	18,000 × 2.5	= 45,000
Resurfacing	1,800 × 15	= 27,000
Construction	1,000/ 1,500 × 30	= 30,000/45,000
		102,000/117,000

i.e. about 110,000/125,000 tons taking other uses into account. These figures are substantially lower than those contained in the Plan objectives -160 000 tons. (The latter figure would imply the construction of some 2,500 km of asphalted road per year, a very optimistic objective).

A similar operation in respect of the year 1985, assuming 25,000 km of asphalted road by this date, would show maximum asphalt consumption at the 180,000/200,000 tons level rather than the 380,000 tons forecast in the Plan.

c) PETROCHEMICAL FEEDSTOCKS

The products involved -naphtha and fuel oil- are not, strictly speaking, energy products. However, it appears difficult at this stage to ascertain whether they are to be produced in addition to quantities previously mentioned. In order to avoid oversizing the refinery by too much, it is assumed that requirements for petrochemicals and fertilizers do not mean increasing the refinery capacity beyond energy product requirements. Consequently, these feedstocks will be drawn either from local petroleum product requirements or more probably from surpluses created by the relative inadequacy of the refining scheme.

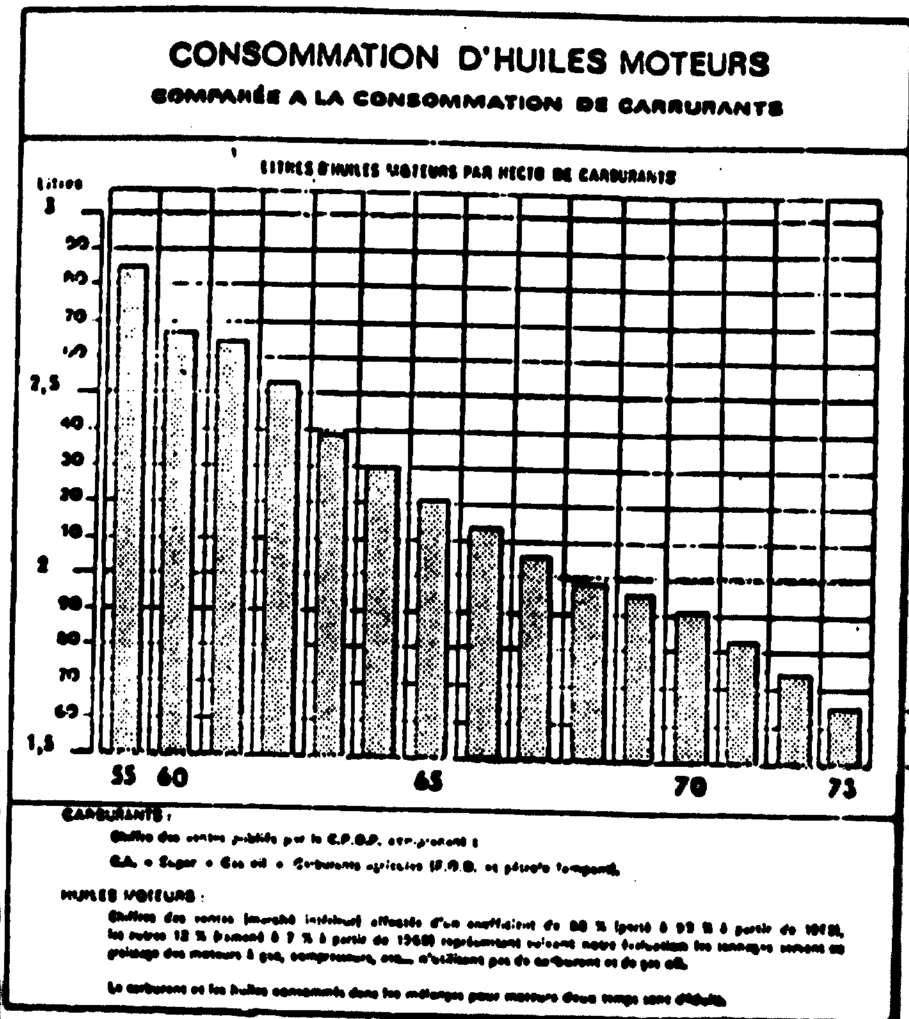


Figure 2.2

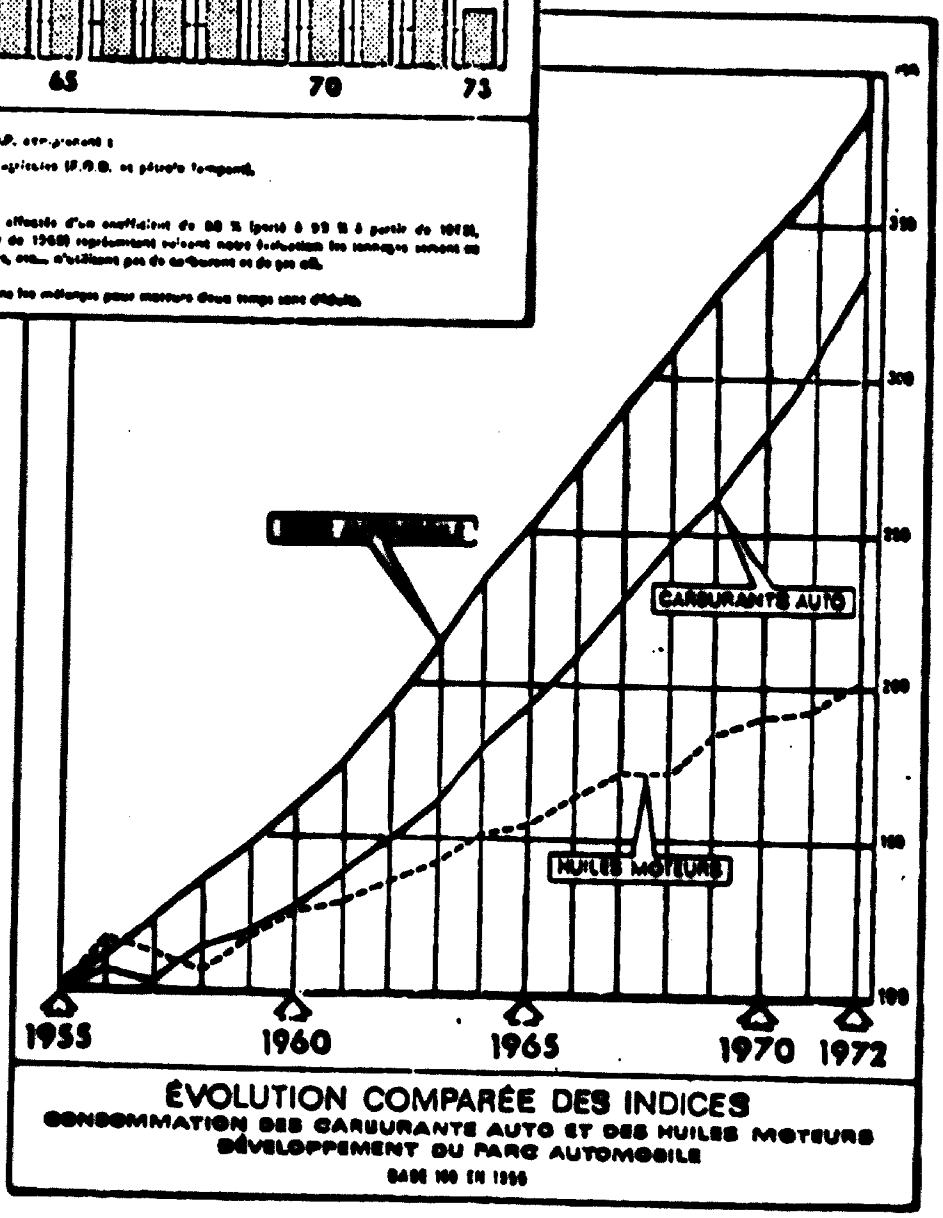


Figure 2.3

TABLE 2.3.

MARKET PROSPECTS FOR PETROLEUM PRODUCTS IN VIETNAM

BEICIP ESTIMATE

(tons)

PRODUCTS	1977	[illegible]	[illegible]
L P G	[illegible]	35 000	70 000
GASOLINES	[illegible]	600 000	870 000
KEROSENE	[illegible]	345 000	500 000
JET FUEL	70 000	130 000	215 000
DIESEL OIL	710 000	1 300 000	2 100 000
FUEL OIL	[illegible]	900 000	1 500 000
TOTAL ENERGY PRODUCTS	2 070 000	3 300 000	5 300 000
ASPHALTS	80 000	110 000	180 000
LUBRICANTS	75 000	100 000	150 000
T O T A L	2 225 000	3 510 000	5 630 000

1.3. REGIONAL BREAKDOWN

There is a lack of data for the evaluation of a regional petroleum product consumption breakdown.

A tentative breakdown has been made from the optimal refinery production pattern, with the sole objective of defining shipping facilities (see chapter 3).

2. CRUDE OIL SUPPLIES

The data presently available is not sufficient to define with accuracy the quality and quantity of Vietnamese crude oil that could be refined.

Although there are many indications that local production could be rapidly developed and might even exceed domestic requirements, the use of imported crude oils cannot a priori be ruled out.

- *LOCAL CRUDE OILS*

The data supplied by PETROVIETNAM shows that future Vietnamese crude oils will be similar in kind to other crude oils now produced in this area - paraffinic and, particularly in the residues, low in sulphur - the commonest of these being MINAS crude (Indonesia), the main characteristics of which are shown in table 2.4. and figure2.4 where MINAS crude is compared with a number of samples taken from Vietnamese fields under unknown conditions.

It was originally intended to situate the representative future Vietnamese crude oil between two limits, one to be MINAS and the other LIGHT SERIA (Brunei).

LIGHT SERIA crude oil is a light crude very well suited suited to the Vietnamese market. This quality is unfortunately not very common in South East ASIA. So LIGHT SERIA constitutes an over-favourable hypothesis but one which should nevertheless be considered in making the ultimate choice of refining scheme. It seems that Vietnamese crude oil quality will probably be much closer to MINAS than to LIGHT SERIA.

<u>MINAS will therefore be taken as typical of future Vietnamese crude oil quality</u>.

• IMPORTED CRUDE OILS

There are many valid reasons for importing crude oil, for example :

1. Local production may be insufficient in quantity

2. Local crude may not be of an appropriate quality, and may in addition require too high investments

3. It may prove more economical to refine imported crude oil rather than a Vietnamese crude which could be valorised on the export market

4. Certain derivatives such as asphalts and lube bases are better obtained from other types of crude more appropriate than those commonly found in South Asia, e.g. MINA.

The commonest crude oils and those most easily available for importation are the MIDDLE EAST crudes (from SAUDI ARABIA, IRAN or IRAQ) which vary between 35 and 30° API. In addition, Russian crudes may also be available.

MIDDLE EAST oil producers are at the moment trying to increase sales of heavy crudes by supplying these along with light crudes. As a result 31° API will be more easily obtained than 34° API. This situation could, however, be counteracted by the availability of 34° API Russian crude with a sulphur content of around 1.5 %.

The imported crude quality taken as average will be ARABIAN LIGHT (33.7° API, 1.7 % S), the main characteristics of which are shown in Table2.4 and figure 2.4.

FIGURE 2.4

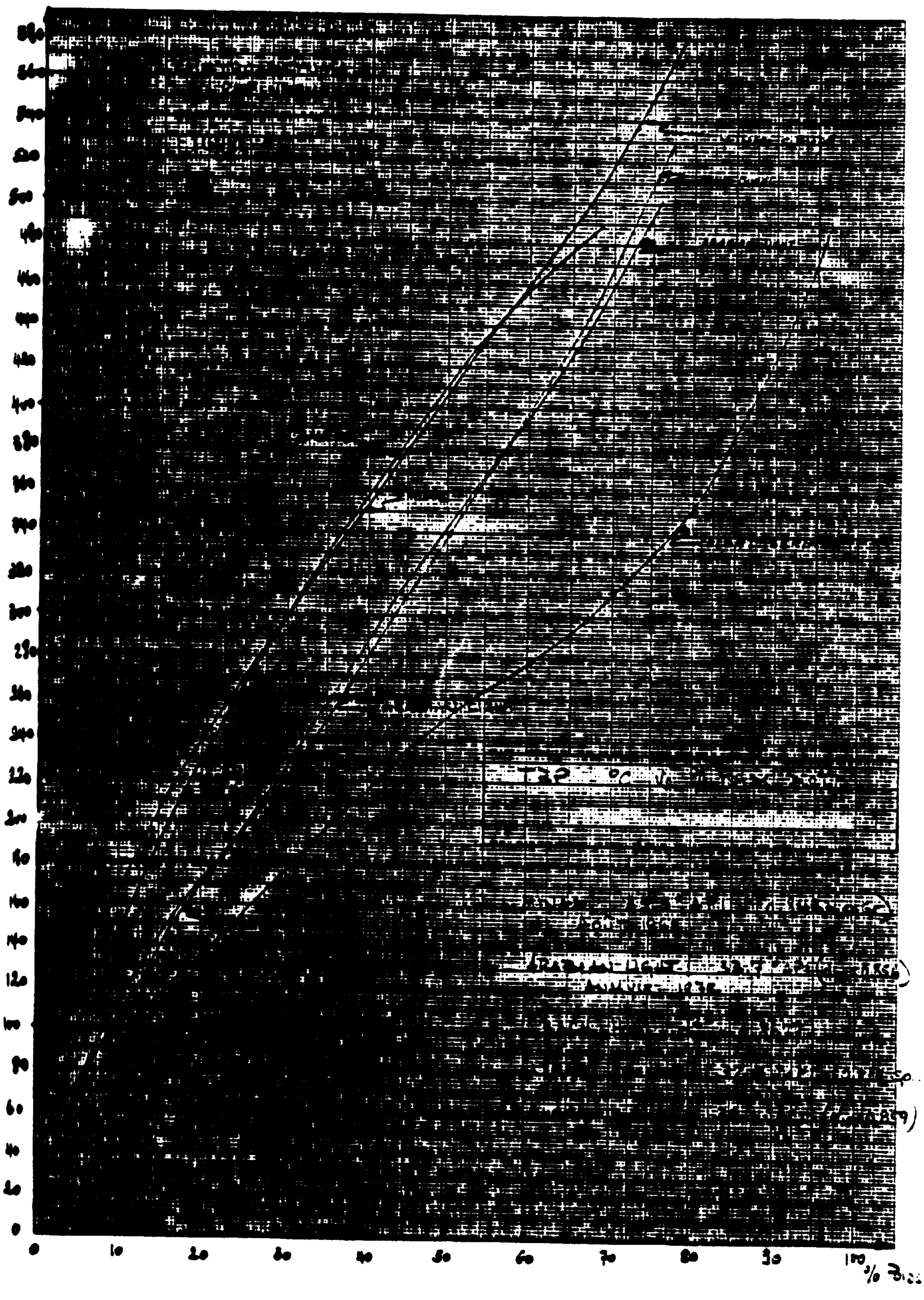


TABLE 2.4

MAIN CHARACTERISTICS OF CRUDE OILS TO BE CONSIDERED

	VIETNAMESE		MINAS	LIGHT SERIA	ARABIANLIGHT	DURAL
	BACH HO	RED RIVER				
. API			35.3	37.7	33.7	31.1
GRAVITY	d_4^{20} = 0.8677	d15 = 0.889	.8483 sp Gr	0.836 sp Gr	d15 = 0.856	d15 = 0.858
SULPHUR CONTENT	0.11	0.18	0.07	0.04	1.72	1.50
POUR POINT ° C	+ 29	+ 42	+ 35	+ 16	- 27	- 5
DISTILLATION (TBP) wt %						
BEFORE 200° C	16.37	6.63	14.5	35.7	25.5	26.2
BEFORE 350° C	38.61	32.30	39.5	79.6	51.5	52.6
RESIDUE 350° C	61.39	67.70	60.5	20.4	48.5	47.4
RESIDUE 350° C +						
SUPHUR CONTENT %	0.17	0.30	0.11	0.14	2.95	2.6
POUR POINT ° C	+ 45	+ 50	+ 46	+ 44	+ 15	+ 21
KIN. VISCOSITY 50° C	28.7	75	110	40	193	300

3. HYPOTHESES AND BASIC DATA FOR REFINING

1. Production plant capacity
2. Production structure
3. General hypotheses
4. Technical data
   - Characteristics of product and specifications
   - Refining facilities
   - Site
5. Economic data

This chapter contains the market, technical and economic data and hypotheses which will serve as a basis for determining the various refining structures to meet domestic demand and for choosing the most appropriate solution in view of VIETNAM's requirements and potential. It therefore deserves very careful study before any decision is taken.

The need for a well-defined approach to the problem of refining in a country like VIETNAM where there remain many unknows with regard to the market and raw materials, means that basic decisions have to be taken in respect of :

- Processing capacity

- Optimum production structure

- Crude oil supplies.

These will be discussed in turn before entering into technical and economic aspects of the refining study.

Note that the paragraph 5 entitled "Economid Data" will relate -with one or two specific exceptions- to all parts of the complex (fertilizers, petrochemicals, etc..).

1. PRODUCTION PLANT CAPACITY

Future plant capacity should be designed so as to allow production to expand in harmony with consumption trends.

Figure 3.1 shows, on the one hand BEICIP's estimate of energy product consumption development and, on the other hand, a number of production growth curves such that consumer requirements can be met with a minimum of surpluses or deficiencies.

Several points must be emphasized :

- Existing production capacity is nil, although consumption is sufficiently high to justify a plant. Bearing in mind implementation schedules, a first refinery could not be expected to start-up before early 1983 at the soonest. By then demand will have reached somewhere between 4.3 and 6 million tons. Minimum capacity of the first refinery must, therefore not be too much in excess of demand. Taking the "lower" consumption curve to be the most reasonable, it results that capacity should not exceed 6 million tons.

- A second refinery will have to be implemented a few years later. A reasonable plan for the second refinery could be capacity similar to that of the first but with an interval of some 3 to 5 years.

- If the capacity of the first is 6 million tons, the second cannot be above 4 million if it is implemented four years later, otherwise there will be from the very beginning an excess over the highest consumption curve.

- The most reasonable plan therefore seems to be 5 million tons capacity by early 1983 to be followed early in 1987 by another of identical size. It will always be possible to adjust the second capacity in order to match later market developments, whereas this would not be so easy if an over-high initial capacity is installed.

- Finally, the first refinery could have to produce asphalt and also feedstocks for the fertilizer complex. To meet expected demand in 1985 an output of around 180,000 tons of road surfacing asphalt per year could be planned. The fertilizer complex will require some 300,000 tons of naphtha or fuel oil, depending on the ammonia manufacturing scheme adopted.

The first refinery will thus involve two possibilities :

- Satisfaction of petroleum-based domestic energy requirements - capacity 5,000,000 tons/year

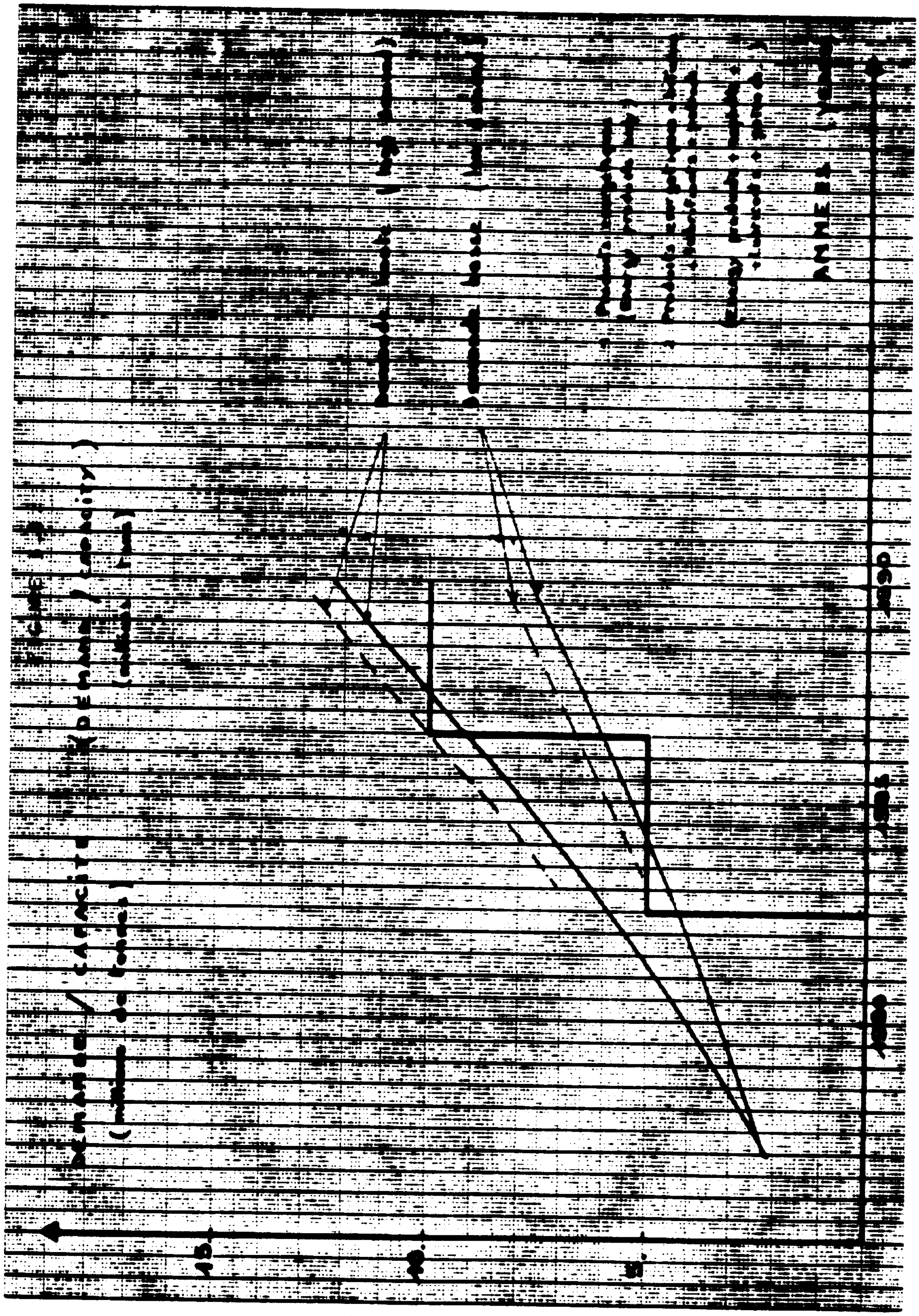
- As above plus asphalt and fertilizer feedstock.

Considering that local or imported crude oils are not very well adapted to the demand pattern of VIETNAM, it does not seem advisable to increase the refining capacity only to cope with asphalt and fertilizer requirements and finally a design capacity of 5,000,000 tons/year will be retained for the refinery.

Asphalt production will only be considered as a consequence of the selected scheme (if this scheme includes a vacuum distillation and if adequate crude oil is available) and it will not be studied further at this stage of the study.

In view of the investment involved it would seem advisable to postpone lube oil production, integrating it into the second refinery.

With total lube oil demand being 150/165 000 tons in 1985, production of some 200,000 tons/yr can be planned for start-up in 1987 so as to perfectly match 1990 market requirements, taking into account the problem of additives and remembering that not all bases can be produced on the site (naphthenic bases for instance). A second asphalt plant could also be added, in view of the road network extension progammme.


DEMANDE / CAPACITE
(DEMAND / capacity)
15
10
5
1985
1990
ANNEES

2. PRODUCTION STRUCTURE

2.1. OVERALL PRODUCTION STRUCTURE

The structure of production should reflect as faithfully as possible that of consumption. However, this principle may not be an economic optimum, if for instance extremely high investments are required or if surpluses can be sufficiently valorized on the export market.

Starting from the selected capacity of 5000000 tons/year and from BEICIP estimates regarding the consumption pattern, an optimal production structure has been established as shown in table 3.1, assuming as an initial hypothesis 5% refinery fuel and losses - this figure in fact varies depending on the production scheme.

TABLE 3.1

OPTIMAL PRODUCTION STRUCTURE

	% wt	10^3 tons
LPG	1.2	60
GASOLINE	15.4	770
KEROSENE	9.8	490
JET FUEL	3.9	195
DIESEL OIL	36.7	1835
FUEL OIL	28.0	1400
FUEL + LOSSES	5.0	250
T O T A L	100.0	5000

2.2. ESTIMATED REGIONAL BREAKDOWN

PETROVIETNAM have worked out an estimated breakdown region by region for 1985, based on an overall demand growth prediction which seems very optimistic, leading to a breakdown between North and South of 45/55 for overall consumption and 40/60 in the case of fuel oil.

In view of the North's energy resources (coal and hydro electricity) and the balance which should be achieved between North and South - population levels being similar - the share of the total taken by the South should perhaps therefore be larger.

For the purposes of this study and particularly in order to assess refinery shipping facilities, an estimate has been made of regional demand breakdown covering the first years of operation (prior to start-up of a second refinery in the South) taking the North/South breakdown to be 40/60. Table 3.2 shows the destination of products by region, assuming the refinery to supply all requirements.

DISTRIBUTION AREAS WITH DISPATCHING CENTERS

Region 1 Northern provinces except HAIPHONG and QUANG NINH
Receiving point : HANOI

Region 2 QUANG NINH + HAIPHONG
Receiving point : HAIPHONG

Region 3 THAN HOA
Receiving point : THAN HOA

Region 4 NGHE TINH
Receiving point : VINH

Region 5 DANANG (BINH TRI THIEN, QUANG NAM, NGHIA BINH, GIA LAI, CONG TUM)
Receiving point : DANANG

Region 6 DAC LAC, PHU KHANH, LAM DONG, THUNA HAI
Receiving point : NHA TRANG

Region 7 Southern provinces
Receiving point : HO CHI MINH City

TABLE 3.2

ESTIMATED DISTRIBUTION OF REFINERY PRODUCTS

	L P G	GASOLINE	JET FUEL	KEROSENE	DIESEL OIL	FUEL OIL	ASPHALTS	TOTAL
REG 1	20	150	80	170	435	250	55	(1) 1 105
REG 2	5	90	20	50	130	100	10	395
REG 3	-	10	-	15	50	(300)	20	415
REG 4	-	80	-	-	150	110	-	
REG 5	-	100	35	20	220	120	20	495
REG 6	-	40	-	50	150	120	10	360
REG 7	35	300	60	105	700	700	65	1 900
TOTAL	[illegible]	770	195	490	1 835	1 400	180	4 750

(1) *without asphalts*

3. GENERAL HYPOTHESES

Technical and economic calculations are using the following hypotheses :

- Material balance are expressed in metric tons
- Yearly rate for plants : 8000 hours or 330 stream days
- The stream factor of the various processing units is taken at 100 % from the start-up
- All economic figures are expressed in US$ mid 1978, assuming the following exchange rate : 1 US$ = 3.25 Dongs

4. TECHNICAL DATA

4.1. CHARACTERISTICS OF PRODUCTS AND SPECIFICATION

In accordance with the optimum manufacturing scheme defined above, products must meet certain specifications.

Specifications proposed by PETROVIETNAM are presented in Appendix 4.

Some specifications are either inappropriate in the Vietnamese context or too rigorous in view of the uncertainties related the type of crude to be processed in the refinery. It therefore seems desirable to allow some margin for the time being at least until fuller local data is obtained.

LPG

This is a blend of propane and butane ; however, the vapour pressure specification (4.9 kg/cm2 at 100°F) considerably limits the propane content. Such a requirement in fact means that the blend can comprise no more than about 10 % propane by volume, as opposed to 25 % for example in FRANCE.

We therefore propose that this specification be brought closer to the french standard for commercial butane (8.5 hpz at 50°C) since meeting the original requirement might involve additional investment for the gas processing plant.

GASOLINE

Most of the gasoline produced has a low octane number.

	% wt	10^3 tons
MON 72	40	308
MON 76	53	408
RON 93	5	39
AVIATION	2	15
TOTAL	100	770

The three gasoline grades will comply with the specifications required with the exception of the distillation specification : initial boiling point (IBP) 40°C minimum.

The three grades must meet the vapour pressure specification (400 to 500 mm hg).

Type 100/130 aviation could be produced only by means of an alkyl-tion unit, but this is not reasonable in view of the small quantity of fuel to be produced. Aviation gasoline produced will be F2 70 grade.

SOLVENTS

Solvent production will not be discussed in detail in this initial study. Solvents will be assumed to be manufactured from the gasoline pool and included under gasoline production.

JET FUEL

Two grades are to be produced :

	% wt	10^3 tons
TC1	70	135
JP4	30	60
T O T A L	100	195

In the case of TC1 jet fuel, meeting the flash point and distillation specifications (initial boiling point 150°C maximum and 10 % vapourised at maximum 165°C) would imply adding light and heavy light and heavy gasoline to the kerosene cut. This grade does not correspond to that recommended by the IATA which is in general use and which has the following main characteristics :

- Specific gravity (60°F/60°F) between 0.775 and 0.830
- Viscosity CS (-30°F) maximum 15
- Flash point °C between 38 and 66
- Distillation : 10% evaporated at maximum 204°C
  50 % evaporated at maximum 232°C
- Freezing point °C maximum - 50
- Aromatics % volume maximum 20

- **Smoke point** mm minimum 25*
- Sulphur content maximum 0.2

The IATA aviation fuel (JP1 in t-he U.S.A. and TRO in FRANCE) has the advantage of being much less volatile than TC1, hence less dangerous to handle.

On the other hand, in the case of TC1 grade off-specification gasoline can be added, if available in the form of gasoline pool surplus. Production of the two types will be compared at a later stage.

KEROSENE

This type of product is usually destined for domestic uses. Bearing this in mind the smoke point specification (20 minimum) could probably be reduced if the direct distillation cut did not reach this level. The same applies to the sulphur content which will be largely determined by the crude oil processed, so that for this purpose desulphurisation should not be necessary.

DIESEL OILS

Three grades are to be produced :

	% wt	10^3 tons
Type 1 CI 45	75	1 375
Type 2 CI 50	10	185
Low speed type DO	15	275
TOTAL	100	1 835

The sulphur content specifications required (0.2 % in the case of types 1 and 2 and 0.5 for LSD type) presume too much of the crude oil quality. In the case of imported crude it is unlikely that the diesel sulphur content should be so low, without preliminary desulphurization. It therefore seems more reasonable not to adopt too strict a standard until crude oil qualities are known. Note that international standards are usually somewhere between 0.5 and 0.7 % or higher.

** or 20 if naphthalene content is below 3*

FUEL OILS

Three grades are to be produced :

		% wt	10^3 tons
Type 1		70	980
Type 2		15	210
Type 3		15	210
	TOTAL	100	1400

As the case of diesels, the same remark as to sulphur content can be applied to fuel oil : it is implied that low sulphur crude oils are to be processed. Should this not be the case, such a requirement would necessitate the construction of fuel oil desulphurisation units with considerable extra investment.

Here again it is wiser to avoid setting up specifications until more is known of the crude oil type to be processed.

Attention should also be drawn to the pour point specification - 21, 20 and 25°C for the three types respectively - which may create some problems for the refiner if the crude oils are not particularly well suited. This requirement too may be cancelled though only in certain cases as not all consumers have their own fuel oil storage heating facilities.

Except if specifically required, it could be advisable for the future to reduce the number of grades of products and particularly for gasoline and diesel oil (only two). This to reduce investment for storage and distribution system.

4.2. REFINING FACILITIES

Included in the refining facilities are :

1. Process units
2. Utility and general facilities
3. Raw material and finished product storage.

Items 1, 2 and 3 together constitute all the installations to be sited - in principle - within the refinery limits.

It is on this basis that the different refining schemes will be compared.

The refining part of the complex also includes :

4. Crude oil delivery facilities
5. Product shipping facilities (sea)
6. A finished product pipeline to HANOI.

Items 1 to 5 will be incorporated into the planned complex, with the optimum layout of the various units discussed in Volume II.

Some preliminary consideration will be given to the finished product pipeline in volume II, chapter 8.

4.2.1. *Process units*

The main units are :

- Atmospheric distillation (and possibly vacuum distillation)
- Gas treatment units
- Conversion units
- Refining units.

Atmospheric distillation

Atmospheric distillation is a means of obtaining a range of cuts from crude oil by distillation at more or less atmospheric pressure.

If necessary heavy ends will be specially distilled in order to obtain cuts for cracking or hydrogenation. The latter operation will take place in a vacuum (20 to 40 mm Hg) to avoid premature, uncontrolled cracking.

According to requirements, specifications to be met and crude oil quality itself, the cuts obtained will be either used as such in blends or processed in conversion or refining units.

Conversion units

These are used to alter the hydrocarbon molecule structure of certain cuts in order to match requirements more closely.

The following units are included in the various schemes :

- Catalytic reforming (see Appendix 5) in which straight run gasolines are converted into high octane gasoline components.
- Catalytic cracking (see Appendix 5)in which heavy distillates from atmospheric and particularly vacuum distillation are converted to high octane gasoline and distillates.
- Hydrocracking (see Appendix 5) - high pressure cracking in the presence of hydrogen, a means of treating a wide range of straight run cuts in order to obtain high grade distillates or gasolines. A hydrogen production unit is required for this operation.

- Coking (see Appendix 5) - high severity thermal cracking, used to convert atmospheric or vacuum residue into lighter products such as gasolines, distillates and coke.

- Visbreaking (see Appendix 5) - less severe thermal cracking designed either to reduce the viscosity of residue or to crack the latter partially and obtain distillate.

Refining units

The function of these is to process cuts obtained by distillation or cracking so as to meet specifications. They include :

- Hydrotreatment, generally used to lower sulphur content and also used to remove components such as mercaptants, di-olefins, etc..

- "MEROX" type sweetening, a means of eliminating mercaptans from light products such as LPG and gasolines.

4.2.2. *Utility production and distribution*

Steam plant and utility production centre located in the refinery fence are supplying all the units with the following utilities :

Steam

High pressure steam	50 bars gage	400°C
Medium pressure steam	15 bars gage	250°C
Low pressure steam	4 bars gage	150-200°C.

Steam is distributed by pipeline to the various users.

Boiler feed water and process water

They are produced in the water demineralization unit from industrial water received from outside.

Cooling water

Industrial water received from outside is used as cooling water. However air-cooling is used as much as possible.

Instrument and service air

Nitrogen

However, a centralized nitrogen network could be considered in case of nitrogen production in fertilizer plant (case with partial oxidation for ammonia production).

All the requirements of electric power are supplied from the external power plant with the following characteristics :

- Voltage : 30 kV
- Period : 50 hz - 3 phases

Power is distributed in the refinery from the main station located inside the fence of the refinery.

4.2.3. General facilities

They include :

- Safety and fire fighting equipment
- Waste water treatment
- Flare system
- Drainage and sewage systems
- Telecommunication and alarm system
- Buildings including
  - control buildings
  - administration building
  - laboratory
  - medical center
  - canteen
  - offices
  - workshops
  - spare parts warehouse
  - laundry
  - guard house
- Roads, parking, fences, etc..

4.2.4. Storage capacity

Main storage requirements are as follows :

- Crude oil storage
- End product storage prior to dispatch
- Storage of semi-finished products from the various units, requiring to be blended to meet specifications
- Slops.

1. Crude oil storage

The crude oil storage system consists of three parts :

- Strategic or reserve storage : a set of tanks, full at all times

- Delivery storage : a set of empty tanks ready to receive a tanker's load at any time

- Operational storage ; in the case of two crude oil grades there would be :

  - 1 tank being filled for each crude oil grade, i.e. 2 tanks in all

  - 1 tank supplying the distillation unit for each crude oil grade, i.e. 2 tanks in all.

a) Storage tank capacity

Total crude oil storage capacity is estimated on the following bases :

- the refinery processes two grades of crude oil

- total crude oil storage capacity corresponds to no more than 45 days' processing under normal conditions.

- Strategic (reserve) storage tanks

VIETNAM being an oil producing country is assured of its supplies. However, the distance from the oil fields to the refinery is such that a strategic storage system will have to be set up close to the refinery. The use of imported crude oil requires the inclusion of a reserve storage system to counter supply fluctuations.

We propose a storage capacity equivalent to 30 days' operation (delivery storage included). This seems appropriate in view of the reliability of domestic crude oil supplies and also of the investment involved (about 250 FF per m3 on a European basis).

- **Delivery storage tanks**

  These depend on tanker size. As tankers of up to 60-70 000 DWT may be used, capacity of 100,000 M3 or 2 x 50,000 m3 must be available.

- **Operational storage tanks**

  If two grades of crude oil are to be processed, there must be four tanks, each with a minimum capacity equivalent to 3 days'production, i.e. 4 x 50,000 m3 = 200,000 m3.

- **Tank sizes**

  A more detailed study would be necessary in order to decide optimum tank size, particularly in the case of reserve tanks, bearing in mind that investment per m3 in storage becomes lower the larger the tank. Other factors have to be taken into consideration, however, in particular the geographical distribution of the tanks and their standardisation.

  The following capacities will be assumed for the purposes of this study (when two grades of crude are processed) :

  . Reserve and delivery storage tanks

    1 month's operation, on the basis of 5,000,000 t/yr, i.e. about 490,000 m3

    with the following breakdown :

    - delivery 2 x 50,000 m3
    - reserve 6 x 65,000 m3

  . Operational storage tanks

    4 x 50,000 m3

  making a total of 690,000 m3, equivalent to 42 days'operation.

b) <u>Positioning of crude oil storage tanks</u>

- Tanker delivery tanks may be sited within the harbour area, within zone B indicated on BEICIP drawing n° 78060.A.101 or within the refinery itself if it is close to the harbour.

- Operational storage tanks must of necessity be sited within the refinery.

- Reserve storage tanks may be sited within the harbour area, in zone B or within the refinery.

Two main alternatives will be considered :

- Delivery and reserve storage tanks in zone B ; operational storage tanks within the refinery

- Delivery, reserve and operational storage tanks within the refinery.

2. End- and semi-finished product storage

End-product storage will be directly related to the refinery production programme.

Construction of an end-products pipeline to HANOI with a capacity of some 1,000,000 m3/yr will mean less storage capacity being required at the refinery assuming it is provided at HANOI where the pipeline terminates. The greater part of the products will, however, be shipped by sea, so that a suitable general assumption at this stage of the study would be :

- end and semi-finished product storage : 21 days' production, destined for the domestic market

- one month's production will be held in storage in the case of export products, i.e. fuel oils.

Estimates will be made on the basis of a 50/50 Vietnamese/imported crude oil supply.

3. Storage of intermediate and slops

The purpose of intermediate storage is twofold :

a) to minimise the effects of one of the processing units coming to a temporary standstill (a few days at most) and

b) to avoid certain units having processing over-capacity in respect of some crude oils.

At this stage storage capacities will be assumed to be directly related to secondary process unit capacities :

- Naphtha : 5 days' operation of the reforming unit at nominal capacity
- Kerosene : 5 days' operation of the hydrotreatment unit at nominal capacity
- Vacuum gas oil : 6 days' operation of the catalytic cracking or hydrocracking unit at nominal capacity
- Residue : 6 days' operation of the coking unit at nominal capacity
- Coking gasoline and distillate : 5 days' operation of the hydrotreatment unit at nominal capacity

When imported crude is being processed, the conversion units -which treat only Vietnamese crude effluents - will be fed from the Vietnamese crude atmospheric residue storage tanks.

Slops storage will in all cases be taken as 2 x 6,000 m3.

4. Coke storage

If petroleum coke is to be produced, the following storage capacities will be required :

- Green coke storage area 1 month's production
- Green coke storage silo 6 days' production
- Calcined coke storage silo 15 days' production.

4.2.5. Crude oil delivery

The atmospheric distillation unit will be supplied with crude oil from the service storage tanks.

Crude oil will be brought to the site by tanker. There are two possible means of doing this :

1. Using medium sized (60 to 70 000 DWT maximum) vessels, with tanker berthing facilities in the harbour.

2. Using larger vessels, with tanker berthing at mooring buyos and crude oil discharge by means of undersea hoses and pipelines.

The solution assumed throughout this study will be alternative 1, which implies minimum investment and seems a good choice if Vietnamese crude oil production is soon to start up. However, this does not mean that BEICIP recommend this solution. Fuller details on sea conditions must be obtained before making a final decision.

In the meantime, a preliminary comparison of the two alternatives is included in Volume II, Chapter 3, which deals with the harbour.

4.2.6. Product shipping facilities

Product shipping will be governed by the refinery production programme. Two alternatives will be considered for the purposes of this study :

<u>Case A</u> : the production programme is exactly matched to demand (see table 3.3)

<u>Case B</u> : production surpluses and deficits occur as as result of the refining scheme not matching demand.

A deficit of 1 million tons of distillates (kerosene and diesel oil) and a corresponding surplus of 1 million tons of fuel oil will be assumed (see table 3.4).

In this event priority would be given to supplying the North, and imports from SINGAPORE used to make up deficits in the HO CHI MINH area.

The two cases do not include asphalts or raw material for fertilizer manufacture.

TABLE 3.3

PRODUCT SHIPPING - CASE A

DESTINATION	PRODUCT	QUANTITY (tons)	MEANS
HANOI	LPG	20 000	Barge or road/rail
	White products	835 000	Pipeline
	Black products	250 000	Barges 500 DWT
HAI PHONG	LPG	5 000	Barge or rail/road
	White products	290 000	Coaster 1000/10000 DWT
	Black products	100 000	Coaster 1000/10000 DWT
THAN HOA - VINH	White products	305 000	Road/rail
	Black products	110 000	Road/rail
DA NANG	White products	375 000	Coasters 1000/10000 DWT
	Black products	120 000	"
NHA TRANG	White products	240 000	Coasters 1000/10000 DWT
	Black products	120 000	"
HO CHI MINGH	LPG	35 000	Coasters 1000/10000 DWT
	White products	1 245 000	"
	Black products	700 000	"
EXPORT	Black products	-	Tankers 30 000 DWT

TABLE 3.4

PRODUCT SHIPPING - CASE [illegible]

DESTINATION	PRODUCT	QUANTITY (tons)	MEANS
HANOI	LPG	20 000	Barge or road/rail
	White products	835 000	Pipeline
	Black products	250 000	Barges 500 DWT
HAI PHONG	LPG	5 000	Barge or rail/road
	White products	280 000	Coaster 1000/10000 DWT
	Black products	100 000	Coaster 1000/10000 DWT
THAN HOA - VINH	White products	305 000	Road/rail
	Black products	110 000	Road/rail
DA NANG	White products	375 000	Coasters 1000/10000 DWT
	Black products	120 000	"
NHA TRANG	White products	240 000	Coasters 1000/10000 DWT
	Black products	120 000	"
HO CHI MINGH	LPG	35 000	Coasters 1000/10000 DWT
	White products	245 000	"
	Black products	700 000	"
EXPORT	Black products	1 000 000	Tankers 30 000 DWT

1. See route

Facilities required will be discussed in Volume II, chapter 3).

The bulk of the production will be shipped by sea. The following vessel characteristics will be taken as average :

	Tonnage (DWT)	Speed (knots)	Use (days/year)
Barges	500	6	345
Coasters	3,000	10	345
Tankers	30,000	13	345

Assuming a 90 % maximum berth occupation rate, requirements have been defined as follows, crude oil delivery included :

__*Case A*__ *(no fuel oil exports)*

. Destination : HAIPHONG, DANANG, NHA TRANG and HO CHI MINH

white and black products :
coasters of 3,000 DWT on average

2 coaster loading berths

+ 1 shared berth for coasters and barges
+ 1 berth for coasters
+ 1 berth for tankers (crude)

. Destination : HANOI

black products :
barges of 500 DWT on average

1 barge loading berth

+ 1 shared berth for coasters and barges

. Destination : HANOI (possibility)

LPG
barges of 500 DWT on average

This gives a total for crude oil discharge and product shipping of 6 loading/unloading berths.

Case 8 (fuel oil exports)

. Destination : HAIPHONG, DANANG, NHA TRANG, HO CHI MINH

white and black products
coasters of 3,000 DWT on average

2 coasters loading berths

+ 1 shared berth for coasters and barges

. Destination : HANOI

black products
barges of 500 DWT on average

1 barge loading berth

+ 1 shared berth for coasters and barges

. Destination : HANOI (possibility)

LPG
barges of 500 DWT on average

. Surplus fuel oil export

black products
barges of 500 DWT on average

1 shared berth for 30,000 DWT tankers and crude tankers

This gives a total of 5 loading/(unloading) berths.

See Volume II, chapter 3.

2. Road/rail

Quantities involved are :

305 000 tons of white products
100 000 tons of black products.

These are destined for THANH HOA and VINH provinces. Equal use will be made of road and rail (50/50).

3. Pipeline

This will be used for white products bound for HANOI.

Capacity : 835 000 tons or about 1 050 000 m3/year
i.e. 150 m3/h.

Approximate length : 210 km.

A preliminary study of the pipeline is contained in Volume II, Chapter 8.

4.3. SITE

Various locations have been studied for the refining facilities. They are studied and compared in Volume II, Chapter 2 and 9.

5. ECONOMIC DATA

5.1. INVESTMENT

As the lack of data makes an accurate estimate of local costs and implementation schedules very difficult, an initial evaluation of investments will be made at this stage and refined in the second stage with reference to the alternative selected.

In the discussion that follows the project is assumed to be implemented by a sole contractor with all of the civil works and some of the erection sub-contracted to local firms, the main contractor making available highly skilled expatriates to reinforce and train local personnel, and the overall duration corresponding to the norm for developing countries in the MIDDLE EAST and South East ASIA.

An erected budget cost will be worked out for each alternative assuming West European conditions and then converted to an erected budget cost for VIETNAM using a ratio which will be estimated in the chapters that follow and which can at this stage of the study and in view of local conditions be no more than an initial approximation.

The cost, whether on a European or Vietnamese basis, will cover :

- Materials costs on site
- Civil works costs
- Erection costs
- Engineering and supervision costs.

Total investment will also include various expenses referred to as Client's expenses, essential for the implementation and satisfactory future operation of the plant and covering :

- Spare parts
- Licence fees
- Initial supplies of chemicals and catalysts
- Pre-operating expenses
- Start-up costs.

5.1.1. INSTALLED COST BUDGET

Below are given some elements for comparing the installed cost budget of a project in VIETNAM with the same in other industrialized areas in WESTERN EUROPE.

The cost which is considered excludes any financing or prefinancing expenses, these expenses being taken into account in our estimates for a later stage. Furthermore, in order to avoid large discrepancies due to the form of contract or the elements of the commercial price, we assume that the cost given hereafter for comparison is a firm price based upon economic conditions prevailing in WESTERN EUROPE in 1978.

1. Local data and conditions

From a general point of view, local availability of both equipment and materials and highly skilled manpower is rather limited. We assume, however, that local firms will be able to perform the totality of the civil engineering and part of the erection works.

No customs duties nor other duties are levied on imported equipment.

The cost of transporting equipment by sea will be at the normal international level. Transportation cost on land will not be high due to the NGHI SON area having been chosen. Only a small part of equipment for civil engineering and erection works will be available. A large part -at least the heaviest equipment- has to be imported.

The major part of the basic material, including cement, will have to be imported.

Additional information will be required at later stage in order to get a better appreciation of local firms' erection and civil engineering potential.

1. *Overall installed cost budget ratio between WESTERN EUROPE and VIETNAM*

There follows an estimate of a possible overall installed cost budget ratio between WESTERN EUROPE and VIETNAM for future projects. The main differences derive from engineering and erection works and levels of provisional and allowance factors between a project in WESTERN EUROPE and a similar one in VIETNAM.

a) *Material and equipment*

Almost all equipment will be imported and locally available supplies can be considered as negligible. For such a project, worldwide procurement can be taken as a basis for material and equipment, and differential in cost should be assumed due to :

- Cost differential between JAPAN, EUROPE and UNITED STATES,
- Impact of currency fluctuations.

Also an additional cost on vendor representatives must be taken into consideration, corresponding to extra-costs due to distance and communication difficulties.

Additional spares especially for rotating equipment can save operating cost and time during the start-up period.

For the above reasons, an incremental cost equivalent to 10 % must be added on to the material and equipment costs.

b) *Transport to site*

Depending on the actual job site location and foreign material and equipment source, the overall cost ratio to move material and equipment from vendor's shop in the source country to a material storage area at site would be affected by the following :

- Source country's inland freight and handling charges,
- Export preparation charges
- Heavy lift charges
- Ocean freight and insurance
- Air freight allowance for a higher than average use of air freight
- Port congestion surcharge if any
- Demurrage, landing and clearance fees.

According to this, transport up to site will cost three times the normal transportation cost for a project in WESTERN EUROPE and the cost will correspond to about 14 % of the ex-workshop material and equipment costs.

c) *Home office engineering services*

Several factors affect home office engineering services, the most important being the following :

1. On engineering design services

   Additional costs for travel and local expenses connected with the engineering design on the site works.

2. On procurement services

   Additional costs for long distance and overseas travel and extra on living expenses, on purchasing, inspection, expediting and forwarding services due to material and equipment shopping around and overseas subcontractors for the field works.

A 10 % incremental factor will be considered for the engineering services.

d) Construction works

Cost of construction and conditions affecting this cost are of major importance in calculating construction ratio between WESTERN EUROPE and VIETNAM. However, the following figures are only preliminary due to the lack of local data.

1. Field engineering - supervision

Several factors affect the cost of field engineering supervision :

- Higher quality field engineering staff
- Larger number of personnel in the field staff
- Higher cost for travel and living expenses
- Higher cost of temporary facilities and communication facilities.

For the above reasons, a conversion ratio of 2 must be applied to European costs.

2. Civil works

Materials will be mostly imported : their costs will be increased by transportation and related costs and their final cost will be double that in EUROPE.

Labour will be mostly performed by local or cheap manpower but the number of manhours expected will be much higher than in EUROPE. On these bases, an overall conversion ratio of 1.2 must be applied to European costs.

3. Erection works

As for field supervision and civil works, several factors affect the cost of erection works.

- Higher cost of highly skilled expatriate labour due to site conditions, travel and living expenses
- Lower cost of local or cheap manpower but lower efficiency

- **Higher indirect costs such as :**
  - equipment rental
  - temporray construction
  - small tools
  - consumables
  - insurance and all indirect costs
  - sub-contractor field supervision.

The overall conversion ratio is very difficult to estimate at this stage. We consider a first figure of 1.7.

e) *Installed cost budget factor on the calculated costs*

To the above calculated costs a provision and allowance factor is commonly applied in calculating an installed cost budget.

As regards the calculated cost, provision and allowance do not have the same level on a European project as on an overseas project in a developing country due to the greater risk associated with such a project.

Considering the preliminary character of this study, provision and allowance on a European project are estimated at 15 %.

For an overseas project, these provisions must take into account additional factors which are called provisions on "translation factor" such as :

- Lack of "hard" estimating data for construction work evaluation
- Allowance for design differentials such as effects of higher ambient temperatures and for differences in soil and seismic conditions.

For the above reasons the provision and allowance are evaluated at 25 %.

6) *Overall installed cost budget ratio between WESTERN EUROPE AND VIETNAM*

As a rough example, table 3.5 gives the overall ratio starting from the cost structure of typical refining projects in EUROPE. This leads to a rounded figure of 1.45 for units erected in NGHI SON.

TABLE 3.5

OVERALL INSTALLED COST BUDGET RATIO

	WESTERN EUROPE	RATIO	VIETNAM
CALCULATED COST			
Material	100	1.10	110
Transport to site	5		15
SUB TOTAL 1	105		125
Home office services	25	1.10	27
Construction works			
- Field engineering supervision	12	2.00	24
- Civil works	60	1.20	72
- Erection works	45	1.70	77
SUB TOTAL 2	117		173
Start-up supervision	3	3.00	9
TOTAL TECHNICAL COST	250	1.34	334
INSTALLED COST BUDGET FACTORS ON THE CALCULATED COSTS			
Provision for contingency	1.15		1.25
INSTALLED COST BUDGET	288	1.45	418

5.1.2. OTHER ITEMS OF THE INVESTMENT COST - WORKING CAPITAL

Beside the delivered and erected budget cost of the plant, other items are to be included into the overall investment cost. These are generally called owner's expenses and include :

- *Spare parts*

  Normal annual consumption for this type of project will correspond to about 4 % of the delivered equipment cost, this to be included in the maintenance costs.

  For the initial spare parts which are included in total investment a basis of 2 years'consumption, or 8 % of the delivered equipment cost is taken. This rather high amount takes into account the long delay for delivery.

- *Initial supplies of catalysts and chemicals*

  These are individually estimated for each plant in the study.

- *Licence and know-how fees*

  On the basis of paid-up royalties, the total amount of licence and know-how fees is also individually estimated for each plant in the study.

- *Pre-operating expenses*

  These are generally expressed as an average percentage of the delivered and erected budget cost of the plant and include among others :

  - Project supervision by the company staff plus consulting firms
  - Progressive personnel hiring expenses
  - Assistance by the contractors and licensors
  - Training expenses

- *Start-up expenses*

  This item includes some losses of feedstocks and utilities during start-up operation.

For the latter two items an average figure of 7 % of the erected budget cost of the plant will be considered.

- *Working capital*

  Beside the fixed capital, a working capital has to be constituted. It may include :

  - Raw and secondary material and finished products inventories

  - Terms of payment for raw material and sales

  and has to be precisely formulated when the project is fully defined.

  At this stage a simplified formulation will be used : not taking into account the terms of payment, and considering only inventories as follows :

  Raw material 1 month of normal production

  Finished products 15 days of production.

  The corresponding cost will be introduced as an item of the operating cost considering a rate of interest on this amount of 10 % per annum.

5.2. OPERATING COST AND OTHER COSTS

For each plant the operating cost will be constituted from the following items :

5.2.1. VARIABLE CHARGES

- *Utilities*

  As a general policy it is assumed that electric power and industrial water required in the various plants will be supplied by centralized power plant and water treatment and distribution system. The characteristics of these two utility centers will be studied later.

  For the purpose of the study the following economic figures will be considered at the gate of each plant :

  - Power (30 kV-50Hz) at 0.1D/KWh or 3¢/KWh
  - Industrial water at 0.17D/m^3 or 5¢/m^3

  Refinery fuel requirements will be directly taken from the refinery production balance. For the other plants a preliminary fuel price will be estimated at 26D/10 kcal or 8 US$/$10^6$ kcal.

  Each plant within the complex will produce for its own use the required quantities of

  steam
  demineralized water
  inert gas
  etc..

  The costs of the latter will be taken into account in investment and connected expenses.

- *Costs of auxiliary materials, chemicals and catalysts*

  Almost all will be imported and then overall costs are estimated for each plant.

5.2.2. FIXED CHARGES

- *Manpower cost* for operation, administration, maintenance and management

  The following average yearly charges are taken, including salaries, employer's contributions, holidays and travel, training charges and in-kind benefits :

. Manager	11 400 D
. Engineers	10 400 D
. Technician/Foremen	8 500 D
. Skilled workers	7 300 D
. Administration employees	7 300 D
. Helpers	6 600 D.

  The cost of maintenance manpower is made up of two parts : cost of maintenance personnel directly attached to the units and an equivalent sum of money corresponding to maintenance subcontracts carried out by external firms.

- *Foreign technical assistance and supervision*

  During the first yearsof production some extra costs due to the utilisation of highly skilled expatriate manpower are considered. They will be estimated at 20 % of the total labour cost.

- *Maintenance costs* include spare parts and some consumable materials such as lubricants, greases, etc.. For the purpose of the study, an average figure of 4 % of the equipment cost is retained.

- *Insurance* is evaluated at 0.6 % of the erected budget cost.

- *General plant overheads* are taken at 30 % of the total manpower cost (including maintenance, administration and foreign technical assistance).

- *Rent for land* is estimated on the basis of 1000 D/ha.

5.2.3. DIRECT COSTS

- *Depreciation*

  A depreciation on a straight line amortization basis over fifteen years (rate 6.66 %) will be assumed for the various depreciable items.

- *Income tax*

  Income tax will be computed at 40 % of the tax basis (gross cash flow minus depreciation).

3.3. COST OF RAW MATERIAL

Raw material will be either local or imported crude oil. In any case crude oil has to be transported either from offshore fields in the South or from exporting terminal abroad up to the receiving facilities at NGHI SON harbour, and the cost of crude oil at the refinery gate will be the sum of :

F.O.B. + transport cost + handling cost

a) TRANSPORT

Both crude oils will be assumed to be transported by the same type of tankers (70/60 000 DWT) compatible with the characteristics of the NGHI SON harbour receiving facilities. On the other hand the effect of utilisation of smaller tanker (30 000 DWT) for Vietnamese crude oil will be evaluated.

The following tables 3.6 and 3.7 give the detailed computation assuming second hand tankers purchased and equipped by a Vietnamese company.

	$/METRIC TON
LOCAL CRUDE OIL	
. Transported with 70 000 DWT	1.13
. Transported with 30 000 DWT	1.85
IMPORTED CRUDE OIL	
. Transported with 70 000 DWT	4.94

b) F.O.B PRICE

The official price for ARABIAN LIGHT is taken as 12.70$/bl or 93.47$/t, and for local crude oil (with the same quality as MINAS) the same price as MINAS considering that the advantage of geographical location of the Vietnamese crude vis a vis Indonesian crude oil when exporting to JAPAN could be balanced by less favourable freight conditions (150 000 DWT tankers can be loaded in DUMAI, INDONESIA)

Vietnamese crude oil 13.55$/bl
or 100.67$/ton

c) **HANDLING EXPENSES**

These expenses are related to the cost of utilization of receiving facilities at NGHI SON harbour. At this stage an average figure of 0.5$/ton of crude is assumed.

d) **COST OF CRUDE OILS IN NGHI SON**

Adding transport and handling costs to FOB Price of the local and imported, the following figures are obtained :

. Local crude oil (35.3° API)

- transported with 70 000 DWT 102.30$/ton
- transported with 30 000 DWT 103.02$/ton

. Imported crude oil (33.7° API)

- transported with 70 000 DWT 98.81$/ton.

It appears very difficult to determine what could be the actual transport conditions of the Vietnamese crude oil but the effect of transport cost on the final CIF cost is small and, as an average value, the following CIF prices will be considered for economic evaluation :

Local crude oil	(CIF)	102.6$/ton
Imported crude oil	(CIF)	98.8$/ton.

TABLE

TRANSPORT COST

	RAS TANURA TO NGHI SON	OIL FIELDS (OFFSHORE) TO NGHI SON	
Distance (n.m.)	4 950	700	700
Tanker size (DWT)	70 000	70 000	30 000
Cargo (tons)	68 100	68 100	29 100
Speed (Knots)			
. loaded	15.25	15.25	15
. ballast	16.5	16.5	16
Sea time (days)			
. loaded	13.52	1.91	1.94
. ballast	12.50	1.77	1.82
Allowance (5%)			
TOTAL	27.3	3.90	3.95
Port time (days)			
. loading	1.5	1.5	1.3
. unloading	1.5	1.5	1.3
TOTAL	3.0	3.0	2.6
Turnaround time (days)	30.3	6.9	6.55
Yearly number of turn around (345 days)	11.4	50	52.7
Number of tankers	6.4	1.5	3.3
Bunker			
. at sea tons/d	65/2	65/2	42/2
. at port tons/d	18/2	18/2	8/2

TABLE

TRANSPORT COST (CONTINUED)

	RAS TANURA TO NGHI SON	OIL FIELDS (OFFSHORE) TO NGHI SON	
TANKER SIZE (DWT)	70 000.	70 000	30 000
TANKER COST ($)	7 700 000	7 700 000	5 100 000
FIXED COSTS ($10^3$$)			
Labor	300	300	300
Maintenance	308	308	204
Insurance/overhead	177	177	117
TOTAL	785	785	621
Financial charges :			
. depreciation . intérêt	10 years 3.9 %	10 years 3.9 %	10 years 3.9 %
TOTAL	1 070	1 070	980
TOTAL FIXED COST $10^3$$	1 855	1 855	1 601
$ / day	5.38	5.38	4.84
Cost for 1 turnaround			
. bunker . fixed costs . port charges	153 162.8 13.5	28.1 37.1 13.5	16.0 30.4 7.5
TOTAL	329.3	78.7	53.9
Unit cost			
$ / ton	4.84	1.13	1.85
Reference WORLDSCALE	63		

5.4. FINISHED PRODUCT PRICES

A marketable product price scale has been worked out on an international basis in the following manner :

a) DOMESTIC MARKET PRICE (ex refinery)

By approximation, a price scale was defined which would be valid for a Japanese or European type market such as is assumed to exist in SINGAPORE and which would allow a refinery adapted to such a market and not yet amortized to cover its operating costs and make a reasonable profit. Note that the prices thus obtained are higher than spot prices on the SINGAPORE international market, the operating cost component of the latter being marginal. Detailed price calculations are shown in Appendix 1 of Volume III.

NGHI SON ex-refinery prices will then be SINGAPORE ex-refinery prices thus calculated plus transport and handling costs between SINGAPORE and NGHI SON (see table 3.8).

b) EXPORT SALES PRICE

Surpluses will have to be sold on international markets where they will be competing with other products sold at marginal cost.

Prices will thus be SINGAPORE spot prices less transport and handling costs. However, low sulphur fuel oil produced from Vietnamese crude will be assumed to be exported direct to JAPAN under exactly the same conditions (FOB) as MINAS residue in INDONESIA.

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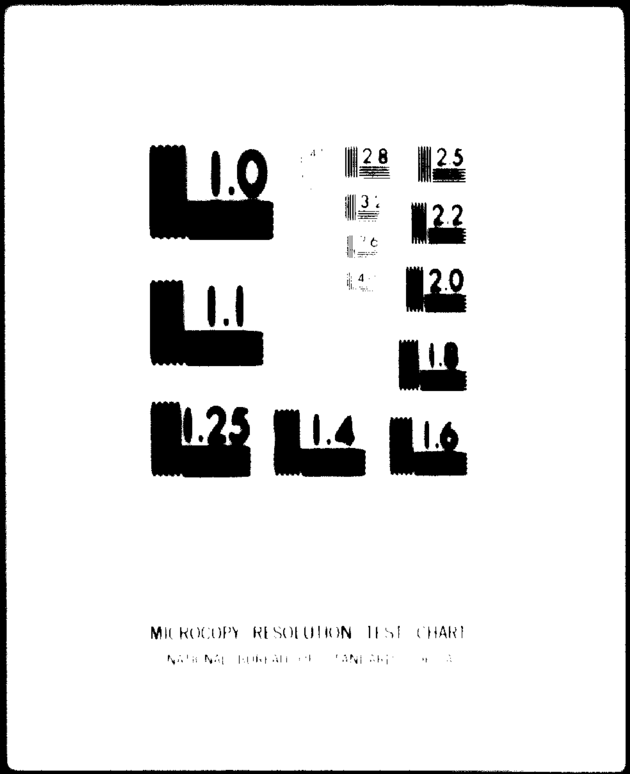

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TABLE 3.6

FINISHED PRODUCT PRICES (IN $/TON)

	Computed ex-refinery F.O.B SINGAPORE	Transport cost	Ex-refinery local	NIGH-SON export	Spot-price SINGAPORE
L P G	131	10	141		
NAPHTHA	150	6	156	124	130
PREMIUM	195	6	201	158	165
REGULAR	180	6	186	148	154
KEROSENE/ JET FUEL	138	5	143	132	137
DIESEL OIL	130	5	135	122	127
FUEL OIL 3% S	82	5	87	67	72
FUEL OIL<0.5% S				90	
COKE				100	

4. REFINING OBJECTIVES

1. Introduction
2. A compromise solution
3. Refining scheme flexibility

1. INTRODUCTION

Refining is a basic industry which in VIETNAM as elsewhere must meet specific objectives. This is the first refinery to be installed in VIETNAM where the market is already sizeable - over 2 million tons - and likely to grow fast.

Satisfying domestic market requirements in terms of both quantity and quality thus represents the prime objective to be attained.

Refining is, however, a complex operation involving a raw material of widely varying quality depending upon its origin and must therefore be adapted to both the raw material and the demand structure. This may require very high investment.

There is a reasonable chance of discovering oil in VIETNAM, both onshore and especially offshore, thus :

> *The refinery must be capable of processing both local and imported crude oil,*

in the event of local production either being insufficient or coming on stream later than expected.

Finally, bearing in mind VIETNAM's financial resources,

> *investment must be kept to a minimum*

while at the same time ensuring technically and economically satisfactory operation.

2. A COMPROMISE SOLUTION

The three objectives to be met by the Vietnamese refining industry, while not completely contradictory, cannot all be achieved together unless the structure and quality of the crude oil treated exactly match domestic market requirements, in which case refining units would be kept to the bare minimum needed to transform crude oil into marketable products without altering its natural structure.

Unfortunately, however, this seems unlikely to be the case, so that the refining scheme adopted will have to be a compromise between the objectives stated in paragraph 1.

Such a compromise is in fact necessary in view of the uncertainties remaining as a local crude oil supplies and the domestic market structure.

It must once again be pointed out that large scale production of Vietnamese crude oil can in no way be taken for granted, and furthermore the assumption that Vietnamese crude would be similar in quality to Indonesian MINAS crude could not -even if preliminary analyses of samples indicate that this is so- be confirmed for several years yet.

The domestic market hypotheses adopted are tenuous, being based on market trends in neighbouring countries rather than on analysis of the Vietnamese market itself.

In view of what is known or assumed about crude oil quality, a compromise solution might take the form of supplying only a small part of the domestic market -corresponding investment being at a minimum- or alternatively covering the total market at the cost of very high investment ; however, a more probable solution (with a view to the future) would be to meet virtually the total market requirements, investment being adequate to allow flexibility of operation.

3. REFINING SCHEME FLEXIBILITY

From a comparison of natural yields of local and imported crude oils with the domestic market structure (see figure 3.1) it can be seen that neither of the two crudes is really suited to this market ; however, they may complement each other in several ways.

The imported crude could make up the gasoline deficit of the local crude ; it also produces less surplus residue. From a quality viewpoint, distillates and residue obtained from the imported crude have a markedly higher sulphur content than the local crude, but at the same time their low temperature is better. A particular point is that local crude residues are unsuited to local use as fuel oil, unless in certain large power stations, but could on the other hand be exported under attractive terms (at present at least) to JAPAN.

Thus with a simple refining scheme local crude could meet only 42 % of total demand compared with 80 % using imported crude and 74 % if the two are processed 50/50. These percentages would of course be affected if the refining scheme extended to include conversion units, but given the complementarity of the two crudes, particularly with regard to fuel oils, it appears preferable to process a blend of the two, even supposing large quantities of local crude to be available.

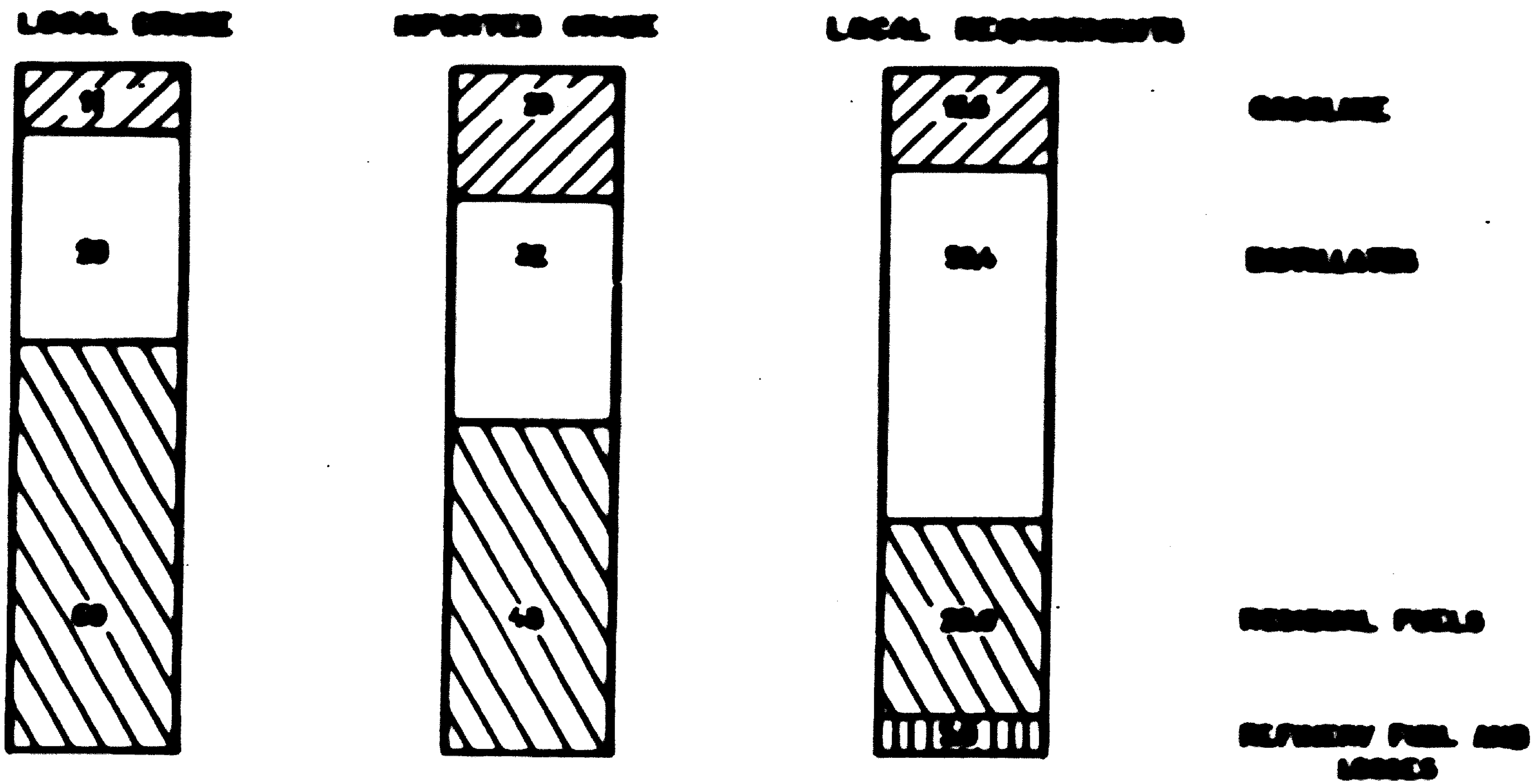
Designing a given scheme to suit a crude blend offers some degree of flexibility in that crudes of differing qualities may be treated.

Thus the refining schemes to be studied and compared will be designed for a 50/50 crude blend then for 100 % local crude.

Further flexibility may be achieved through the inclusion of conversion units to transform heavy cuts into lighter ones, thus allowing crudes very different from those for which the refinery was designed to be processed satisfactorily.

Here again it is evident that maximum flexibility implies maximum investment, hence the need to find a compromise solution.

CRUDE OIL CHARACTERISTICS AND DEMAND STRUCTURE



5. REFINING SCHEMES

1. Cases and schemes studied
2. Description of schemes
3. Technico-economic comparison
   - Unit capacity
   - Production balance
   - Utility balance
   - Investment
   - Operating costs
   - Economic comparison
4. Results

1. CASES AND SCHEMES STUDIED

Two alternatives designs will be studied :

- 50/50 % local/imported crude

  For each of the schemes the economic results of processing : - a 50/50 blend
  - local crude only
  - imported crude only

  will be compared.

- 100 % local crude

  The different local crude processing schemes will be compared.

Comparison of natural yeilds, i.e. after distillation, of local and imported crudes with the market structure reveals a surplus of residue accompanied by a deficit of middle distillates.

On the basis of *Scheme n°1 : hydroskimming*, which does not allow crude transformation other than reforming of naphtha to give high octane gasoline components and the treatment -if necessary- of gases, light gasoline and kerosene, other schemes by which surplus residue may be partially or wholly converted into lighter products have been studied.

SCHEME N°2 : CATALYTIC CRACKING

Catalytic cracking feedstock can be prepared from atmospheric residue by vacuum distillation. This method means less residue is obtained and at the same time gives a large quantity of gasoline and very little additional middle distillate.

SCHEME N°3 : CATALYTIC CRACKING/COKING

The addition of a coking step to the previous scheme offers a means of both removing a great deal of the fuel oil surplus and producing satisfactory distillates and also coke.

The coke could not be valorised unless the quality were good, so only local crude (low sulphur and metal content) will be treated in the coking unit. This scheme will, however, inevitably lead to surpluses of naphtha.

SCHEME N°4 : HYDROCRACKING

This is an alternative version of scheme n°2 with hydrocracking instead of catalytic cracking. By this means a lot of distillates - including jet fuel - can be produced from heavy cuts.

SCHEME N°5 : HYDROCRACKING/COKING

As in scheme n°3 the inclusion of a coking unit means that there is no longer a surplus of fuel oil. It is in fact this scheme that yields the maximum of distillates without a gasoline surplus. Here again only local crude cuts are treated in the coking unit.

SCHEME N°6 : THERMAL CRACKING/COKING

By this scheme atmospheric residue (from local crude only) is directly transformed into gasoline, distillates and coke.

SCHEME N°7 : VISBREAKING/THERMAL CRACKING

This is a variation on the previous scheme, atmospheric residue being treated in a two-stage thermal cracker. It would be possible only if the refinery were designed for 100 % local crude.

2. REFINING SCHEMES DESCRIPTION

The following table shows the types of design and feed according to the different refining schemes which have been considered.

A number of 22 refinery production balances have been established.

The following descriptions include :

- A brief refining scheme presentation
- A block flow diagram showing the material balance expressed in metric tons per year
- A refinery finished products breakdown.

  In the refinery finished products breakdown the refinery fuel gas/fuel oil consumption is not taken into account.

  The refinery fuel will be supplied by :

  - refinery fuel gas by-product
  - atmospheric/vacuum residues excess products
  - fuel oil net production.

  The finished products composition from intermediate products is shown for each refining scheme and types of design and feed in Appendix 2 .

TYPE OF DESIGN	50 % MINAS 50 % ARABIAN			100 % MINAS
TYPE OF FEED	50 % MINAS 50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
REFINING SCHEMES				
1. HYDROSKIMMING	●	●	●	●
2. F.C.C.	●	●	●	●
3. FCC/COKER	●	●	-	●
4. H C K	●	●	●	●
5. H C K/COKER	●	●	-	●
6. TC/COKER	●	●	-	●
7. VB/TC	-	-	-	●

5.1. REFINING SCHEME N°1 - HYDROSKIMMING

a) SCHEME PRESENTATION

It is the simpler refining scheme which have been considered. It includes the following process units :

- an atmospheric crude distillation
- a naphtha stabilization, a splitting unit
- a catalytic reformer
- a kerosene hydrotreater
- a gas plant with a DEA treater
- two MEROX units for LPG and light gasoline sweetening.

The main characteristics of this scheme are shown in table 5.1.a.

When ARABIAN LIGHT crude is processed, a kerosene hydrotreater and a light gasoline MEROX are required in order to respect the specification of gasoline and domestic kerosene.

The gasoline production is maximized with an overhead cut point of 185°C.

The atmospheric residue cut point, for both crudes processed, is 370°C, this value permits a fairly good distillates recovery and makes possible the integration of the heavy atmospheric gas oil to the diesel oil pool.

When MINAS crude is processed, in order to respect the jet fuel freezing point specification and to maximize the gasoline production, the cut points of the SR kerosene are 170 and 220°C. 300°C final cut point gas oil may be used to the manufacture of the domestic kerosene.

When this refining scheme n°1 is run with a 50/50 MINAS/ARABIAN feed, gasoline, jet fuel and fuel oil productions are in accordance with the market forecast.

TABLE : 5-1-a

REFINING SCHEME N° 1 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM. DISTILLATION					
- OVERHEAD	170-	185-	170-	185-	170-
- KEROSENE E.P.	220	240	220	240	220
- L.A.G.O.	300	340	300	340	300
- ATM. RESIDUE	370+	370+	370+	370+	370+
. CAT. REFORMER					
- FEED CUT	80/170	75/185	80/170	85/185	80/170
- SEVERITY (RON)	95	95	95	95	95
. LIGHT GASOLINE MEROX	NOT USED		NOT USED		NO
- FEED CUT		C5/75		C5/85	
. KEROSENE HYDROTREATER	NOT USED		NOT USED		NO
- FEED CUT		185/240		185/240	

6) BLOCK FLOW DIAGRAM AND MATERIAL BALANCE

See the following sketches :

- 78060.A.101 MINAS/ARABIAN 50/50 DESIGN BASIS
- 78060.A.111 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % MINAS FEED MATERIAL BALANCE
- 78060.A.121 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % ARABIAN FEED MATERIAL BALANCE
- 78060.A.131 100 % MINAS DESIGN BASIS

c) **TOTAL REFINERY PRODUCTION**

See the following tables :

5.1.c.1 MINAS/ARABIAN 50/50 DESIGN BASIS

5.1.c.2 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

5.1.c.3 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % ARABIAN FEED MATERIAL BALANCE

5.1.c.4 100 % MINAS DESIGN BASIS

TABLE 5.1.c.1

REFINING SCHEME N° 1

CASE : MINAS/ARABIAN LIGHT 50/50 %

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	85	1.7
. LPG	36	0.7
. GASOLINE	687	13.7
. JET FUEL	195	3.9
. KEROSENE	245	4.9
. DIESEL OIL	1 115	22.3
. FUEL OIL	1 400	28.0
. EXCESS PRODUCTS		
ATMOSPHERIC RESIDUUM 370+ MINAS	1 237	24.7
. LOSSES	-	
. TOTAL PRODUCTION	5 000	

TABLE : 5.1.c.2

REFINING SCHEME N°1

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

P R O D U C T S	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	49	1,0
. LPG	20	0,4
. GASOLINE	429	8,6
. JET FUEL	195	3,9
. KEROSENE	245	4,9
. DIESEL OIL	1217/1055	24,3/21,1
. FUEL OIL	0/162	0/3,2
. EXCESS PRODUCTS - ATMOSPHERIC RESIDUUM 370$^+$	2845	56,9
. LOSSES	-	-
. TOTAL PRODUCTION	5000	

REMARK : 1 - SUMMER PRODUCTION/WINTER PRODUCTION

TABLE : 5.1.c.3

REFINING SCHEME N° 1

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % ARABIAN FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	103	2,1
. LPG	45	0,9
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	245	4,3
. DIESEL OIL	1325	26,5
. FUEL OIL	1400	28,0
. EXCESS PRODUCTS - ATMOSPHERIC RESIDUUM 370°	317	19,4
. LOSSES		
. TOTAL PRODUCTION	5000	

TABLE : 5.1.6.4 .

REFINING SCHEME N°1

BASE 100 % MINAS CRUDE DESIGN BASIS
100 % MINAS FEED

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
• FUEL GAS	40	1.0
• LPG	20	0.4
• GASOLINE	420	8.4
• JET FUEL	150	3.0
• KEROSENE	245	4.9
• DIESEL OIL	1217/1056	24.3/21.1
• FUEL OIL	0/162	0/3.2
• EXCESS PRODUCTS - ATMOSPHERIC RESIDUUM 370+	2846	56.8
• LOSSES	-	-
• TOTAL PRODUCTION	5000	

REMARK : 1 - SUMMER PRODUCTION/WINTER PRODUCTION

8.2. REFINING SCHEME N° 2 - CATALYTIC CRACKING (FCC)

a) SCHEME PRESENTATION

The FCC refining scheme includes all the refining scheme n°1 process units plus :

- a vacuum distillation
- a catalytic cracking (FCC)
- a FCC gasoline MEROX unit.

The vacuum distillation unit is used to prepare a 370/550 cut suitable to feed the FCC unit.

In the 50/50 MINAS/ARABIAN type of design this FCC unit is designed to provide C_5/170 gasoline yields from 30 to 36 % weight. When a 100 % MINAS feed is processed the market gasoline demand can be met running the FCC unit with a maximum gasoline yield of 36 %.

In the 100 % MINAS design basis the gasoline yield is 30 % weight (low severity).

The vacuum residue cut point, for both crudes processed is 550°C ; this value is the most reasonable taking into account the pressures/temperatures limits in the vacuum tower flash zone.

This refining scheme n°2 never satisfies the diesel oil and domestic kerosene requirements.

TABLE : 5-2-e

REFINING SCHEME N° 2 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM DISTILATION					
- OVERHEAD	170^-	165^-	170^-	155^-	170^-
- KEROSENE E.P.	220	240	220	240	220
- L.A.G.O. E.P.	300	340	300	340	300
- ATM. RESIDUE	370^+	370^+	370^+	370^+	370^+
. CAT. REFORMER					
- FEED CUT	80/170	65/165	80/170	65/155	80/170
- SEVERITY (RON)	95	95	95	95	95
. LIGHT GASOLINE MEROX	NOT USED		NOT USED		NO
- FEED CUT		C5/85		C5/85	
. KEROSENE HYDROTREATER	NOT USED		NOT USED		NO
- FEED CUT		165/240		155/240	
. VACUUM UNIT		NOT USED			
- VAC. RESIDUE	550^+		550^+	550^+	550^+
. FCC UNIT		NOT USED			
- FEED CUT	370/350		370/550	370/550	370/550
- GASOLINE YIELD (%WT)	30		36	30	30

b) BLOCK FLOW DIAGRAM and MATERIAL BALANCE

See the following sketches :

- 78060.A.102 MINAS/ARABIAN 50/50 DESIGN BASIS
- 78060.A.112 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % MINAS FEED MATERIAL BALANCE
- 78060.A.122 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % ARABIAN FEED MATERIAL BALANCE
- 78060.A.132 100 % MINAS DESIGN BASIS

c) TOTAL REFINERY PRODUCTION

See the following tables :

5.2.c.1 MINAS/ARABIAN 50/50 DESIGN BASIS

5.2.c.2 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

5.2.c.3 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % ARABIAN FEED MATERIAL BALANCE

5.2.c.4 100 % MINAS DESIGN BASIS

TABLE 5.2.c.1

REFINING SCHEME N° 2

CASE : MINAS/ARABIAN 50/50 %

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	120	2.4
. LPG	60	1.2
. GASOLINE	770	15.4
. JET FUEL	195	3.9
. KEROSENE	336	6.7
. DIESEL OIL	1 297.5	26.0
. FUEL OIL	1 400	28.0
. EXCESS PRODUCTS	788	15.8
- ATMOSPHERIC RESIDUUM 370+ MINAS	477.5	9.6
- VACUUM RESIDUUM 550+ MINAS	310.5	6.2
. LOSSES		
- FCC COKE	33.5	0.7
. TOTAL PRODUCTION	5 000	

TABLE : 5.2.c.2

REFINING SCHEME N° 2

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100% MINAS FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	85	1,7
. LPG	60	1,2
. GASOLINE	636	12,7
. JET FUEL	195	3,9
. KEROSENE	245	4,9
. DIESEL OIL	1217/1065	24,3/21,1
. FUEL OIL	465/789	9,3/15,8
. EXCESS PRODUCTS	2062/1900	41,2/38
- ATMOSPHERIC RESIDUUM 370° MINAS	1900	38
- VACUUM RESIDUUM 550° MINAS	162/0	3,2/0
. LOSSES		
- FCC COKE	36	0,7
. TOTAL PRODUCTION	5000	

[redacted] : 1 - SUMMER PRODUCTION / WINTER PRODUCTION

TABLE : 5.2.c.3

REFINING SCHEME N° 2

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % ARABIAN FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	132,5	2,7
. LPG	60	1,2
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	245	4,3
. DIESEL OIL	1550	31,0
. FUEL OIL	1400	28,0
. EXCESS PRODUCTS	630,5	12,6
- GASOLINE 65/135	107,5	2,1
- ATMOSPHERIC RESIDUUM 370°	523	10,5
. LOSSES		
- FCC COKE	17	0,3
. TOTAL PRODUCTION	5000	

TABLE : 5.2.c.4

REFINING SCHEME N° 2

CASE : 100 % MINAS CRUDE DESIGN BASIS

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	152	3.0
. LPG	60	1.2
. GASOLINE	770	15.4
. JET FUEL	195	3.9
. KEROSENE	245	4.9
. DIESEL OIL	1150	23.0
. FUEL OIL	700	14.0
. EXCESS PRODUCTS	1661	33.2
- ATMOSPHERIC RESIDUUM 370°	955	19.1
- VACUUM RESIDUUM 550°	706	14.1
. LOSSES		
- FCC	67	1.3
. TOTAL PRODUCTION	5000	

2.3. REFINING SCHEME N°3 - FCC/COKING

a) SCHEME PRESENTATION

The FCC/coking refining scheme includes all the refining scheme n°2 process units plus :

- a delayed coker unit
- a cracked gasoline/light gas oil hydrotreater
- a calciner
- a steam reformer.

The delayed coker feed is a mixture of MINAS atmospheric and vacuum residues.

In the 50/50 MINAS/ARABIAN type of design when 50/50 mixture is processed, the catalytic reformer is fed with only the ARABIAN 65/165 heavy gasoline cut.

The steam reformer is used only in the case of 100 % MINAS crude design basis. In the 50/50 type of design the hydrogen coming from the catalytic reformer satisfies the hydrotreater needs.

Delayed coking of ARABIAN residuum has not been considered ; sulphur content of the calcined coke produced would be too high.

When this refining scheme n°3 is run with a 50/50 MINAS/ARABIAN feed, LPG gasoline, jet fuel, domestic kerosene and fuel oil productions are in accordance with the market forecasts. Diesel oil demand is not satisfied ; total gasoline, fuel gas, and calcined coke are in excess.

TABLE : 5-3-e

REFINING SCHEME N° 3 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM. DISTILLATION				-	
- OVERHEAD	150⁻	185⁻	170⁻		150⁻
- KEROSENE E.P.	220	240	220		220
- L.A.G.O. E.P.	300	340	300		300
- ATM. RESIDUE	370⁺	370⁺	370⁺		370⁺
. CAT. REFORMER	NOT USED			-	
- FEED CUT		85/185	80/170		85/150
- SEVERITY (RON)		95	95		95
. LIGHT GASOLINE MEROX	NOT USED		NOT USED	-	NO
- FEED CUT		C5/85			
. KEROSENE HYDROTREATER	NOT USED		NOT USED	-	NO
- FEED CUT		185/240			
. VACUUM UNIT		NOT USED		-	
- VAC. RESIDUE	550⁺		550⁺		550⁺
. FCC UNIT		NOT USED		-	
- FEED CUT	370/550		370/550		370/550
- GASOLINE YIELD (%Wt)	36		30		30
. DELAYED COKER		NOT USED		-	
- FEED CUT	550⁺		550⁺		370⁺/550⁺
. COKER HYDROTREATER		NOT USED		-	
- FEED CUT	C5/350		C5/350		C5/350
. STEAM REFORMER	NO	NO	NO	-	
- FEED CUT					C5/150

e) BLOCK FLOW DIAGRAM AND MATERIAL BALANCE

See the following sketches :

- 78060.A.103 MINAS/ARABIAN 50/50 DESIGN BASIS
- 78060.A.113 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % MINAS FEED MATERIAL BALANCE
- 78060.A.123 100 % MINAS DESIGN BASIS

c) **TOTAL REFINERY PRODUCTION**

See the following tables :

- 5.3.c.1 MINAS/ARABIAN 50/50 DESIGN BASIS
- 5.3.c.2 MINAS/ARABIAN 50/50 DESIGN BASIS 100 % MINAS FEED MATERIAL BALANCE
- 5.3.c.3 100 % MINAS DESIGN BASIS

TABLE 5.3.c.1

REFINING SCHEME N° 3

CASE : MINAS/ARABIAN 50/50 %

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	221.5	4.4
. LPG	60	1,2
. GASOLINE	770	15.4
. JET FUEL	195	3.9
. KEROSENE	490	9.8
. DIESEL OIL	1 433	28.7
. FUEL OIL	1 400	28.0
. EXCESS PRODUCTS	353.5	7.1
- TOTAL GASOLINE SR C5/150 MINAS	197	3.9
- ATMOSPHERIC RESIDUUM 370+ ARABIAN	53.5	1.1
- CALCINED COKE	103	2,1
. LOSSES	77	1.5
- FCC COKE	54	1,1
- CALCINATION	23	0,4
. TOTAL PRODUCTION	5 000	

TABLE : 5.3.c.2

REFINING SCHEME N° 3

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
• FUEL GAS	190,5	3,8
• LPG	60	1,2
• GASOLINE	770	15,4
• JET FUEL	195	3,9
• KEROSENE	245	4,9
• DIESEL OIL	1500	30,0
• FUEL OIL	700	14,0
• EXCESS PRODUCTS	1265,5	25,3
- ATMOSPHERIC RESIDUUM 370° MINAS	1162,5	23,2
- CALCINED COKE	103	2,1
• LOSSES	74	1,5
- FCC COKE	51	1,0
- CALCINATION	23	0,5
• TOTAL PRODUCTION	5000	

TABLE : 5.3.c.3

REFINING SCHEME N° 3

CASE : 100 % MINAS CRUDE DESIGN BASIS

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	308	5,1
. LPG	60	1,2
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	490	3,8
. DIESEL OIL	1474	29,5
. FUEL OIL	1200	24,0
. EXCESS PRODUCTS	388	7,8
- GASOLINE	180	3,6
- CALCINED COKE	208	4,2
. LOSSES	117	2,4
- FCC	67	1,3
- CALCINATION	45	1,0
- STEAM REFORMING	5	0,1
. TOTAL PRODUCTION	5000	

2.4. REFINING SCHEME N°4 - HYDROCRACKING

a) SCHEME PRESENTATION

The HCK refining scheme includes all the refining scheme n°1 process units plus :

- a vacuum distillation
- an hydrocracking unit
- a steam reformer unit.

The vacuum distillation unit is used to prepare a 370/550 cut suitable to feed the HCK unit.

The HCK unit is designed to produce middle distillates for diesel oil manufacture.

The HCK 150/185 kerosene cut is entirely used to produce jet fuel.

A steam reformer fed with the catalytic reformer off-gas, supplies hydrogen to the HCK unit.

When this refining scheme n°4 is run with a 50/50 MINAS/ARABIAN feed, LPG, gasoline, domestic kerosene and fuel oil productions are in accordance with the market forecasts. Diesel oil demand is not satisfied.

In the case of 100 % MINAS design basis gasoline demand is not entirely satisfied and the fuel oil production represents only 60 % of the needs.

TABLE : 5-4-e

REFINING SCHEME N° 4 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM. DISTILLATION					
- OVERHEAD	170^-	165^-	170^-	155^-	170^-
- KEROSENE E.P.	280	240	280	240	280
- L.A.G.O. E.P.	350	340	350	340	350
- ATM. RESIDUE	370^+	370^+	370^+	370	370
. CAT. REFORMER					
- FEED CUT	80/170	65/165	80/170	65/155	80/170
- SEVERITY (RON)	95	95	95	95	
. LIGHT GASOLINE MEROX	NOT USED		NOT USED		NO
- FEED CUT		C5/65		C5/65	
. KEROSENE HYDROTREATER	NOT USED		NOT USED		NO
- FEED CUT		165/240		155/240	
. VACUUM UNIT		NOT USED			
- VAC. RESIDUE	550^+		550^+	550^+	550^+
. HCK UNIT		NOT USED			
- FEED CUT	370/550		370/550	370/550	370/550
. STEAM REFORMER		NOT USED			
- FEED CUT	CAT. REFORM. OFF-GAS		CAT. REFORM OFF-GAS	CAT. REFORM. OFF-GAS	CAT. REFORM. OFF-GAS

b) BLOCK FLOW DIAGRAM AND MATERIAL BALANCE

See the following sketches :

- 78060.A.104 MINAS/ARABIAN 50/50 DESIGN BASIS
- 78060.A.114 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % MINAS FEED MATERIAL BALANCE
- 78060.A.124 MINAS/ARABIAN 50/50 DESIGN BASIS
  100 % ARABIAN FEED MATERIAL BALANCE
- 78060.A.134 100 % MINAS FEED DESIGN BASIS

c) TOTAL REFINERY PRODUCTION

See the following tables :

5.4.c.1 MINAS/ARABIAN 50/50 DESIGN BASIS

5.4.c.2 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

5.4.c.3 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % ARABIAN FEED MATERIAL BALANCE

5.4.c.4 100 % MINAS FEED DESIGN BASIS

TABLE 5.4.e.1

REFINING SCHEME N° 4

CASE : MINAS/ARABIAN 50/50 %

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	71.5	1.4
. L P G	60	1.2
. GASOLINE	770	15.4
. JET FUEL	195	3.9
. KEROSENE	490	9.8
. DIESEL OIL	1 560	31.2
. FUEL OIL	1 400	28
. EXCESS PRODUCTS VACUUM RESIDUUM 550+ MINAS	448.5	9.0
. LOSSES -STEAM REFORMER	5	0.1
. TOTAL PRODUCTION	5 000	

TABLE : 5.4.c.2

REFINING SCHEME N° 4

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	39	0,8
. LPG	60	1,2
. GASOLINE	589	11,8
. JET FUEL	195	3,9
. KEROSENE	245	4,9
. DIESEL OIL	1500	30,0
. EXCESS PRODUCTS - ATMOSPHERIC RESIDUUM 370°	1367	27,3
. LOSSES - STEAM REFORMER	5	0,1
. TOTAL PRODUCTION	5000	

TABLE : 5.4.c.3

REFINING SCHEME N° 4

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % ARABIAN FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	90	1,8
. LPG	60	1,2
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	271	5,4
. DIESEL OIL	1835	36,7
. FUEL OIL	1400	28,0
. EXCESS PRODUCTS	369	7,4
- GASOLINE 65/155	132	2,6
- ATMOSPHERIC RESIDUUM 370°	237	4,8
. LOSSES - STEAM REFORMER	10	0,2
. TOTAL PRODUCTION	5000	

TABLE : 5.4.c.4

REFINING SCHEME N° 4

CASE : 100 % MINAS CRUDE DESIGN BASIS

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	66	1,3
. LPG	60	1,2
. GASOLINE	752	15,0
. JET FUEL	165	3,3
. KEROSENE	490	9,8
. DIESEL OIL	1835	36,7
. FUEL OIL	850	16,8
. EXCESS PRODUCTS - VACUUM RESIDUUM 550+	742	14,9
. LOSSES - STEAM REFORMER	10	
. TOTAL PRODUCTION	5000	

2.5. REFINING SCHEME N°5 - HCK/COKING

a) SCHEME PRESENTATION

The HCK/Coking refining scheme includes all the refining scheme n°4 process units plus :

- a delayed coker
- a cracked gasoline/light gas oil hydrotreater
- a calciner.

The delayed coker feed is the MINAS 550+ vacuum residue.

Delayed coking of ARABIAN residue has not been considered ; sulphur content of the calcined coke produced would be too high. In this refining scheme the HCK yields are slightly different from those shown in the refining scheme n°4 : the gasoline production is higher. Part of the heavy gasoline is sent to the catalytic reformer.

The steam reformer make-up for hydrogen production is part of total gasoline C_5/150.

This refining scheme may satisfy all the market forecasts, except the fuel oil production. Calcined coke is in excess.

TABLE : 5-5-a

REFINING SCHEME N° 5 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM. DISTILLATION				-	
- OVERHEAD	150^-	165^-	170^-		150^-
- KEROSENE E.P.	220	240	220		220
- L.A.G.O. E.P.	300	340	300		300
- ATM. RESIDUE	370^+	370^+	370^+		370^+
. CAT. REFORMER				-	
- FEED CUT	(65/150 SR (80/150 HCK	65/165	(80/170 SR (80/150 HCK		(65/150 SR (80/150 HCK
- SEVERITY (RON)	95	95	95		95
. LIGHT GASOLINE MEROX	NOT USED		NOT USED	-	NO
- FEED CUT		C5/65			
. KEROSENE HYDROTREATER	NOT USED		NOT USED	-	NO
- FEED CUT		165/240			
. VACUUM UNIT		NOT USED		-	
- VACUUM RESIDUE	550^+		550^+		550^+
. HCK UNIT		NOT USED		-	
- FEED CUT	370/550		370/550		370/550
. DELAYED COKER		NOT USED		-	
- FEED CUT	550^+		550^+		550^+
. COKER HYDROTREATER		NOT USED		-	
- FEED CUT	C5/350		C5/350		C5/350
. STEAM REFORMER		NOT USED		-	
- FEED CUT	CAT.REFORM. OFF-GAS		CAT.REFORM. OFF-GAS		CAT.REFORM. OFF-GAS + C5/150 GASOLINE

6) BLOCK FLOW DIAGRAM AND MATERIAL BALANCE

See the following sketches :

78060.A.105	MINAS/ARABIAN 50/50 DESIGN BASIS
78060.A.115	MINAS/ARABIAN 50/50 DESIGN BASIS 100 % MINAS FEED MATERIAL BALANCE
78060.A.135	100 % MINAS FEED DESIGN BASIS

c) TOTAL REFINERY PRODUCTION

See the following tables :

5.5.c.1	MINAS/ARABIAN 50/50 DESIGN BASIS
5.5.c.2	MINAS/ARABIAN 50/50 DESIGN BASIS 100 % MINAS FEED MATERIAL BALANCE
5.5.c.3	100 % MINAS FEED DESIGN BASIS

TABLE 5.5.c.1

REFINING SCHEME N° 5

CASE : MINAS/ARABIAN 50/50 %

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	140	2.8
. LPG	60	1.2
. GASOLINE	770	15.4
. JET FUEL	186	3.8
. KEROSENE	480	9.6
. DIESEL OIL	1 836	36.7
. FUEL OIL	1 379	27.6
. EXCESS PRODUCTS		
- CALCINED COKE	103	2.1
. LOSSES	28	0.6
- CALCINATION	23	0.5
- STEAM REFORMER	5	0.1
. TOTAL PRODUCTION	5 000	

TABLE : 5.5.c.2

REFINING SCHEME N° 5

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	112	2,2
. LPG	60	1,2
. GASOLINE	640	12,8
. JET FUEL	195	3,9
. KEROSENE	245	4,9
. DIESEL OIL	1700	34,0
. FUEL OIL	1200	24,0
. EXCESS PRODUCTS	820	16,4
- ATMOSPHERIC RESIDUUM 370$^+$ MINAS	717	14,3
- CALCINED COKE	103	2,1
. LOSSES	28	0,6
- STEAM REFORMER	5	0,1
- CALCINATION	23	0,5
. TOTAL PRODUCTION	5000	

TABLE : 5.5.c.3

REFINING SCHEME N° 5

CASE : 100 % MINAS CRUDE DESIGN BASIS

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	221	4,4
. LPG	60	1,2
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	490	9,8
. DIESEL OIL	1835	36,7
. FUEL OIL	1209	24,2
. EXCESS PRODUCTS - CALCINED COKE	168	3,4
. LOSSES	52	1,0
- CALCINATION	37	0,7
- STEAM REFORMER	15	0,3
. TOTAL PRODUCTION	5000	

2.6. REFINING SCHEME N°6 - THERMAL CRACKING/COKING

a) SCHEME PRESENTATION

The TC/coking refining scheme includes all the refining scheme n°1 process units plus :

- a TC/coking unit
- a cracked gasoline/light gas oil hydrotreater
- a calciner.

The TC/coking unit feed is the MINAS atmospheric residue 370+.

TC/coking of ARABIAN residue has not been considered. Sulphur content of the calcined coke produced would be too high.

In the TC/coking unit the major part of the 350+ heavy gas oil is thermally cracked in order to increase the light distillates yields ; a little part is used as fuel cutter stock.

Part of the heavy gasoline 80/170 produced in the TC/coking unit is used as feed of the catalytic reformer in order to satisfy the gasoline needs.

When a 50/50 MINAS/ARABIAN mixture is processed this refining scheme may satisfy all the market forecasts except the diesel oil production.

In the case of 100 % MINAS design basis diesel oil and fuel oil needs are not satisfied.

TABLE : 5-6-e

REFINING SCHEME N° 6 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM. DISTILLATION				-	
- OVERHEAD	150-	185-	170-		150-
- KEROSENE E.P.	220	240	220		220
- L.A.G.O. E.P.	300	300	300		300
- ATM. RESIDUE	370+	370+	370+		370+
. CAT. REFORMER				-	
- FEED CUT	85/150 SR 80/170 TC	85/185	80/170 SR 80/170 TC		85/150 SR 80/170 TC
- SEVERITY (RON)	95	95	95		95
. LIGHT GASOLINE MEROX	NOT USED		NOT USED	-	NO
- FEED CUT		C5/85			
. KEROSENE HYDROTREATER	NOT USED		NOT USED	-	NO
- FEED CUT		185/240			
. TC/COKING UNIT		NOT USED		-	
- FEED CUT	370+		370+		370+
. COKER HYDROTREATER		NOT USED		-	
- FEED CUT	C5/350		C5/350		C5/350

b) BLOCK FLOW DIAGRAM AND MATERIAL BALANCE

See the following sketches :

78060.A.106	MINAS/ARABIAN 50/50 DESIGN BASIS
78060.A.116	MINAS/ARABIAN 50/50 DESIGN BASIS 100 % MINAS FEED MATERIAL BALANCE
78060.A.136	100 % MINAS DESIGN BASIS

c) TOTAL REFINERY PRODUCTION

See the following tables :

5.6.c.1 MINAS/ARABIAN 50/50 DESIGN BASIS

5.6.c.2 MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

5.6.c.3 100 % MINAS DESIGN BASIS

TABLE : 5.6.c.1

REFINING SCHEME N° 8

CASE : MINAS/ARABIAN 50/50 %

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	151,5	3,0
. LPG	60	1,2
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	490	9,8
. DIESEL OIL	1430	28,6
. FUEL OIL	1400	28,0
. EXCESS PRODUCTS	479,5	9,6
- ATMOSPHERIC RESIDUUM 370° MINAS	370,5	7,4
- CALCINED COKE	109	2,2
. LOSSES		
- CALCINATION	24	0,5
. TOTAL PRODUCTION	5000	

TABLE : 5.6.c.2

REFINING SCHEME N° 6

CASE : MINAS/ARABIAN 50/50 DESIGN BASIS
100 % MINAS FEED MATERIAL BALANCE

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	118,5	2,4
. LPG	60	1,2
. GASOLINE	645	12,9
. JET FUEL	195	3,9
. KEROSENE	245	4,9
. DIESEL OIL	1400	28,0
. FUEL OIL	900	18,0
. EXCESS PRODUCTS	1412,5	28,3
- ATMOSPHERIC RESIDUUM 370⁺ MINAS	1303,5	26,1
- CALCINED COKE	109	2,2
. LOSSES		
- CALCINATION	24	0,5
. TOTAL PRODUCTION	5000	

TABLE 15.6.c.3

REFINING SCHEME N° 6

CASE : 100 % MINAS CRUDE DESIGN BASIS

TOTAL REFINERY PRODUCTION

P R O D U C T S	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	192	3,8
. LPG	60	1,2
. GASOLINE	770	15,4
. JET FUEL	195	3,9
. KEROSENE	490	9,8
. DIESEL OIL	1500	30,0
. FUEL OIL	1100	22,0
. EXCESS PRODUCTS	646	12,9
- ATMOSPHERIC RESIDUUM 370$^+$	434	8,7
- CALCINED COKE	212	4,2
. LOSSES		
- CALCINATION	47	1,0
. TOTAL PRODUCTION	5000	

2.7. REFINING SCHEME N°7 - VISBREAKING/THERMAL CRACKING

a) SCHEME PRESENTATION

The VB/TC refining scheme include all the refining scheme n°1 process units plus :

- a VB/TC unit
- a cracked gasoline/light gas oil hydrotreater.

The VB/TC refining scheme has been considered with only one type of design and feed : 100 % MINAS.

The VB/TC unit feed is the MINAS atmospheric residuum 370^{+}.

VB/TC of ARABIAN residue has not been considered ; the ARABIAN residue 370+ may be used as fuel oil without any processing to decrease viscosity or pour point.

VB/TC operation on MINAS 370+ residue would require pilot assays in order to determine if the visbroken residuum produced may be used as fuel oil without any sedimentation problems.

This refining scheme may satisfy the market demand of fuel oil but light products and diesel oil needs are not satisfied.

TABLE : 5-7-a

REFINING SCHEME N° 7 MAIN CHARACTERISTICS

TYPE OF DESIGN	50 % LOCAL CRUDE 50 % IMPORTED CRUDE				100 % LOCAL CRUDE
TYPE OF FEED	50 % MINAS	50 % ARABIAN	100 % MINAS	100 % ARABIAN	100 % MINAS
. ATM. DISTILLATION - OVERHEAD - KEROSENE E.P. - L.A.G.O. E.P. - ATM. RESIDUE	-	-	-	-	170⁻ 220 300 370⁺
. CAT. REFORMER - FEED CUT - SEVERITY (RON)	-	-	-	-	80/170 95
. LIGHT GASOLINE MEROX - FEED CUT	-	-	-	-	NO
. KEROSENE HYDROTREATER - FEED CUT	-	-	-	-	NO
. VB/TC UNIT - FEED CUT	-	-	-	-	370^{+}
. VB/TC HYDROTREATER - FEED CUT	-	-	-	-	C5/350

b) **BLOCK FLOW DIAGRAM AND MATERIAL BALANCE**

See the following sketche :

78060.A.137 100 % MINAS DESIGN BASIS

c) TOTAL REFINERY PRODUCTION

See the following table

5.7.c.1 100 % MINAS DESIGN BASIS

TABLE : 5.7.c.1

REFINING SCHEME N° 7

CASE : 100 % MINAS CRUDE DESIGN BASIS

TOTAL REFINERY PRODUCTION

PRODUCTS	TOTAL 10^3 T/YEAR	% OF TOTAL PRODUCTION
. FUEL GAS	85	1,7
. LPG	60	1,2
. GASOLINE	522	10,4
. JET FUEL	195	3,9
. KEROSENE	245	4,9
. DIESEL OIL	1362	27,2
. FUEL OIL	1400	28,0
. EXCESS PRODUCTS - ATMOSPHERIC RESIDUUM 370°	1250	25,0
. LOSSES		
. TOTAL PRODUCTION	5000	

3. TECHNO-ECONOMIC COMPARISON

This part presents the main elements of the technical and economic comparison of the various cases and schemes studied.

Successively for

Design 50/50 % MINAS/ARABIAN LIGHT

with 50/50 % local/imported crude feed run
with 100 % local crude feed run
with 100 % imported crude feed run

Design 100 % MINAS
with 100 % local crude feed run

the following tables show :

1. Process unit design capacities
2. Total refinery production
3. Utility balances
4. Investment calculation
5. Operating cost calculation
6. Economic comparison.

PROCESS UNITS DESIGN CAPACITIES
DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
5,0 MM T/YEAR OF 50/50 MINAS/ARABIAN CRUDES

10^3T/YEAR

PROCESS UNITS \ REFINING SCHEME	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. ATMOSPHERIC CRUDE DISTILLATION	5000	5000	5000	5000	5000	5000
. NAPHTA STABILIZATION AND SPLITTING	1153	953	953	953	953	953
. CATALYTIC REFORMER	584	413,5	292	492	492	584
. KEROSENE HYDROTREATER	230	330	330	330	330	330
. LIGHT GASOLINE SR MEROX	194	97	97	97	97	97
. GAS PLANT	173	225	306,5	156,5	225	236,5
. LPG MEROX	85	85	85	85	85	85
. DEA TREATER	103	140	221,5	71,5	140	151,5
. VACUUM DISTILLATION	-	945	1422,5	1422,5	1422,5	-
. CATALYTIC CRACKER (FCC)	-	525	795	-	-	-
. FCC GASOLINE MEROX	-	157,5	288	-	-	-
. HYDROCRACKER	-	-	-	795	795	-
. THERM CRACKER/COKER	-	-	-	-	-	925
. DELAYED COKER	-	-	627,5	-	627,5	-
. COKER HYDROTREATER	-	-	320	-	320	617,5
. CALCINER	-	-	126	-	126	133
. STEAM REFORMER (NM^3/H PURE H_2 BASED ON REFORMING OFF-GAS)	-	-	-	21000	21000	-

TOTAL REFINERY PRODUCTION

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED

5.0 RR T/YEAR OF 50/50 MINAS/ARABIAN CRUDES

PRODUCTS (10^3 T/YEAR)	MARKET STRUCTURE	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. LPG	60	36	60	60	60	60	60
. GASOLINE	770	687	770	770	770	770	770
. JET FUEL	195	195	195	195	195	195	195
. KEROSENE	490	245	336	490	490	490	490
. DIESEL OIL	1835	1115	1297.5	1433	1560	1835	1430
. FUEL OIL PRODUCTION		1454	1442	1400	1538	1379	1490
. REFINERY FUEL OIL CONSUMPTION		54	42	0	138	112	90
. NET FUEL OIL PRODUCTION	1400	1400	1400	1400	1400	1267	1400
. EXCESS PRODUCTS	-	1183	746	367.5	290.5	103	389.5
- GASOLINE		-	-	197	-	-	-
- ATMOSPHERIC RESIDUUM		1183	477.5	53.5	-	-	280.5
- VACUUM RESIDUUM		-	268.5	-	310.5	-	-
- CALCINED COKE		-	-	103	-	103	109
- FUEL GAS		-	-	14	-	-	-
. LOSSES	250	-	33.5	77	5	28	24
- FCC COKE			33.5	54	-	-	-
- CALCINER			-	23	-	23	24
- STEAM REFORMER			-	-	5	5	-
. TOTAL REFINERY NET PRODUCTS (% NET PRODUCTS/CRUDE FEED)	4750 (95)	3678 (74)	4058.5 (81)	4348 (87)	4475 (90)	4617 (92)	4345 (87)
. TOTAL REFINERY PRODUCTS (% NET PROD/TOTAL PRODUCTS)	4750 (100)	4861 (76)	4804.5 (84)	4715.5 (92)	4785.5 (94)	4720 (98)	4734.5 (92)

UTILITY BALANCES

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
5,0 MM T/YEAR OF 50/50 MINAS/ARABIAN CRUDES

U T I L I T I E S	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. WATER/STEAM						
-DESIGN CAPACITIES OF . BOILERS (T/H)	3 X 30	3 X 40	3 X 50	3 X 35	3 X 40	3 X 35
-DESIGN CAPACITIES OF . DEMINERALIZATION/ BFW (T/H)	100	150	180	150	160	130
-DESIGN CAPACITIES OF . COOLING TOWER (M^3/H)	2500	3500	4700	3600	4100	3000
-WATER NET CONSUMPTION (M3/H) (MAXIMUM)	210	300	300	310	340	260
. ELECTRIC POWER (KWH/H)						
- PROCESS UNITS CONSUMPTION	4610	6055	10070	10700	14965	10020
- TOTAL REFINERY CONSUMPTION	9200	11350	17020	16275	21035	16365
. FUEL						
- TOTAL FUEL FIRED (MM KCAL/H)	171	202	255	262	315	302
- FUEL OIL CONSUMPTION (10^3 T/YEAR)	54	42	0	130	112	90

INVESTMENT CALCULATION
DESIGN BASIS MINAS/ARABIAN LIGHT 50/50 %

IN THOUSAND US$ 1978

UNITS / CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
PROCESS UNITS							
Atmospheric crude distillation	21 000	21 000	21 000	21 000	21 000	21 000	
Naphtha stabilization/splitter	4 900	4 350	4 350	4 350	4 350	4 350	
HDS/catalytic reformer	20 650	15 900	12 300	18 200	18 200	20 650	
Kerosene hydrotreater	4 000	5 200	5 200	5 200	5 200	5 200	
Gas plant	2 750	3 250	4 000	2 650	3 250	3 350	
DEA treater	1 500	1 800	2 400	1 150	1 800	1 900	
LPG sweetening	1 200	1 200	1 200	1 200	1 200	1 200	
S.R. light gasoline sweet.	2 000	1 250	1 250	1 250	1 250	1 250	
Vacuum distillation		8 600	11 500	11 500	11 500	-	
Catalytic cracker (FCC)		21 400	29 200	-	-	-	
FCC gasoline sweetening		2 200	3 300	-	-	-	
Hydrocracker			-	34 400	34 400	-	
Thermal cracker/coker			-		-	21 750	
Delayed coker			12 750		12 750	-	
Coker hydrotreater			6 600		6 600	10 800	
Calciner			6 700		6 700	6 950	
Coke handling and storage			7 500		7 500	7 800	
Hydrogen plant				12 100	12 100	-	
TOTAL 1	58 000	86 230	129 250	113 000	147 800	106 200	
UTILITY - OFFSITES							
Utility	15 100	20 950	27 000	19 500	23 250	15 150	
Storage	65 100	64 900	64 400	64 400	64 400	64 600	
General services	17 800	22 150	31 500	27 500	35 500	24 400	
Buildings	15 700	18 700	20 000	18 700	20 000	18 700	
Site preparation	18 800	19 000	24 450	19 000	24 450	19 000	
TOTAL 2	132 500	145 700	167 350	149 100	167 600	141 450	

INVESTMENTS (CONTINUED)

IN THOUSAND $ 1978

CASES / UNITS	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
PROCESS UNITS	58 000	86 230	129 250	113 000	147 000	106 200	
UTILITY OFFSITES	132 500	145 700	167 350	149 100	167 600	141 450	
ERECTED COST - EUROPE BASIS	190 500	231 930	296 600	262 100	315 400	247 650	
TOTAL COST EUROPE (1.15)	219 000	267 000	341 000	301 000	363 000	285 000	
TOTAL COST VIETNAM (1.45)	310 000	306 000	495 000	437 000	526 000	413 000	
Spare parts	7 600	9 260	11 870	10 490	12 620	9 910	
Catalysts and chemicals	1 025	1 825	740	2 200	2 300	1 170	
Royalties	920	1 750	2 550	3 000	4 300	1 500	
Pre-operating and start up expenses	22 300	27 000	34 650	30 590	36 820	20 910	
TOTAL INVESTMENT (excluding financial charges)	349 845	424 835	544 810	404 000	582 040	454 500	
WORKING CAPITAL	65 925	66 552	67 359	67 204	67 730	67 010	

OPERATING COST

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
5.0MMT/YEAR OF CRUDE (50/50%)

UNITS 10³US$ \ CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. ook.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack ook.	7 Visb./Th Cok.
OPERATING COST							
Variable charges							
. Utility (power, water)	2 292	2 304	4 237	4 030	5 184	4 031	
. Catalysts and chemicals	265	700	985	800	830	420	
TOTAL	2 557	3 004	5 222	4 830	6 014	4 451	
Fixed charges							
. Labour	1 500	1 600	1 870	1 600	1 870	1 600	
. Technical assistance	300	340	370	340	370	340	
. Maintenance material	3 800	4 630	5 935	5 245	6 310	4 955	
. Insurance	1 910	2 320	2 970	2 620	3 160	2 400	
. Overhead	540	610	670	610	610	610	
. Land rent	50	50	50	50	50	50	
. Interest on working capital	6 593	6 855	6 736	6 720	6 773	6 701	
TOTAL	14 693	16 295	18 601	17 275	19 203	16 826	
TOTAL OPERATING COST	17 250	19 800	23 823	22 105	25 217	21 277	
$/ton	3.45	3.90	4.76	4.42	5.04	4.26	
WORKING CAPITAL							

ECONOMIC COMPARISON

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED

5MMT/YEAR OF CRUDE

CASES / UNITS 10^3US$	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
SALES							
Local	468 680	522 161	565 475	582 620	608 174	565 070	
Export	106 470	57 140	40 663	24 840	10 300	36 145	
TOTAL	575 150	580 301	606 138	607 460	618 474	601 215	
RAW MATERIAL							
Local	256 500	256 500	256 500	256 500	256 500	256 500	
Imported	247 000	247 000	247 000	247 000	247 000	247 000	
TOTAL	503 500	503 500	503 500	503 500	503 500	503 500	
OPERATING COST	17 250	19 899	23 823	22 105	25 217	21 277	
GROSS CASH FLOW	64 408	65 902	78 815	81 855	89 757	76 438	
TOTAL INVESTMENT	349 845	424 835	544 810	404 000	582 040	454 500	
PAY OUT (Years)	6.4	6.4	6.9	5.9	6.5	5.9	
Δ PO (1)	+ 1.6	+ 0.7	+ 0.4	+ 0.2	+ 0.1	+ 0.3	
Δ (2)	+ 4.2	+ 1.6	+ 0.8	+ 0.4	+ 0.2	+ 0.7	
DEPRECIATION	23 323	28 322	36 321	32 272	38 802	30 305	
TAX BASIS	31 085	37 580	42 494	49 583	50 955	46 133	
TAX (40 %)	12 434	15 032	16 998	19 833	20 382	18 453	
A.T. CASH FLOW	41 974	50 870	61 817	62 022	69 375	57 985	
PAY OUT (years) (A.T.)	8.3	8.3	8.8	7.8	8.4	7.8	

(1) *export sales - 10 %*
(2) *export sales - 20 %*

RUNNING PROCESS UNITS CAPACITIES AS PER % OF DESIGN
DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
100 % MINAS CRUDE FEED RUN
5,0 MM T/YEAR OF CRUDE

PROCESS UNITS \ REFINING SCHEME	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. ATMOSPHERIC CRUDE DISTILLATION	100	100	100	100	100	100
. NAPHTA STABILIZATION AND SPLITTING	46	56	56	56	56	56
. CATALYTIC REFORMER	55	65	100	80	87	84
. KEROSENE HYDROTREATER	0	0	0	0	0	0
. LIGHT GASOLINE SR MEROX	0	0	0	0	0	0
. GAS PLANT	48	74	90	75	86	85
. LPG MEROX	40	95	100	93	96	96
. DEA TREATER	48	61	86	55	80	78
. VACUUM DISTILLATION	-	100	100	100	100	-
. CATALYTIC CRACKER (FCC)	-	100	100	-	-	-
. FCC GASOLINE MEROX	-	100	81	-	-	-
. HYDROCRACKER	-	-	-	100	100	-
. THERM. CRACKER/COKER	-	-	-	-	-	100
. DELAYED COKER	-	-	100	-	100	-
. COKER HYDROTREATER	-	-	100	-	100	100
. CALCINER	-	-	100	-	100	100
. STEAM REFORMER (Nm^3/H PURE H_2 BASED ON REFORMING OFF-GAS)	-	-	-	100	100	-

TOTAL REFINERY PRODUCTION
DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
100 % MINAS FEED RUN
5,0 MM T/YEAR OF CRUDE

PRODUCTS (10^3 T/YEAR)	MARKET STRUCTURE	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. LPG	60	20	60	60	60	60	60
. GASOLINE	770	429	635	770	589	640	645
. JET FUEL	195	195	195	195	195	195	195
. KEROSENE	490	245	245	245	245	245	245
. DIESEL OIL	1835	1217/1055	1217/1055	1500	1500	1700	1400
. FUEL OIL PRODUCTION		71/233	521/845	700	1153	1330	1026
. REFINERY FUEL OIL CONSUMPTION		71	56	0	153	130	126
. NET FUEL OIL PRODUCTION	1400	0/162	465/789	700	1000	1200	900
. EXCESS PRODUCTS	-	2774	2006/1844	1265,5	1214	690	1286,5
- GASOLINE		-	-	-	-	-	-
- ATMOSPHERIC RESIDUUM		2774	1900/1844	1162,5	1214	587	1177,5
- VACUUM RESIDUUM		-	106/0	-	-	-	-
- CALCINED COKE		-	-	103	-	103	109
- FUEL GAS		-	-	-			
. LOSSES	250	-	36	74	5	28	24
- FCC COKE			36	51	-	-	-
- CALCINER			-	23	-	23	24
- STEAM REFORMER			-	-	5	5	-
. TOTAL REFINERY NET PRODUCTS (% NET PRODUCTS/CRUDE FEED)	4750 (95)	2106 (42)	2817/2979 (56)/(60)	3470 (69)	3589 (72)	4040 (81)	3445 (69)
. TOTAL REFINERY PRODUCTS (% NET PROD./TOTAL PRODUCTS)	4750 (100)	4880 (43)	4823 (58)/(62)	4735,5 (73)	4800 (75)	4730 (85)	4731,5 (73)

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UTILITY BALANCES
DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
100 MINAS CRUDE FEED RUN
5,0 MM T/YEAR OF CRUDE

UTILITIES	1 HYDROSKIM.	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. WATER STEAM						
- DESIGN CAPACITIES OF . BOILERS (T/H)	3 X 30	3 X 40	3 X 50	3 X 35	3 X 40	3 X 25
. DEMINERALIZATION/ BFW(T/H)	100	150	180	150	160	130
. COOLING TOWER (M^3/H)	2500	3500	4700	3600	4100	3800
- WATER NET CONSUMPTION (M^3/H) (MAXIMUM)	170	270	340	270	310	230
. ELECTRIC POWER (KWH/H)						
- PROCESS UNITS CONSUMPTION	4000	5500	10200	10100	14300	10300
- TOTAL REFINERY CONSUMPTION	8400	10700	16300	15500	19300	15600
. FUEL						
- TOTAL FUEL FIRED (MM KCAL/H)	150	177	241	240	302	306
- FUEL OIL CONSUMPTION(10^3T/YEAR)	71	56	0	153	130	126

OPERATING COST

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED

100 % MINAS FEED RUN (5MMT/YEAR)

UNITS \ CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
OPERATING COST							
Variable charges							
. Utility (power, water)	2 084	2 676	4 040	3 820	4 756	3 836	
. Catalysts and chemicals	220	680	730	740	775	365	
TOTAL	2 304	3 356	4 970	4 560	5 531	4 201	
Fixed charges							
. Labour	1 500	1 690	1 870	1 690	1 870	1 690	
. Technical assistance	300	340	370	340	370	340	
. Maintenance material	3 800	4 630	5 935	5 245	6 310	4 955	
. Insurance	1 910	2 320	2 970	2 620	3 160	2 480	
. Overhead	540	610	670	610	670	610	
. Land rent	50	50	50	50	50	50	
. Interest on working capital	6 592	6 655	6 755	6 683	6 725	6 675	
TOTAL	14 692	16 295	18 620	17 238	19 155	16 800	
TOTAL OPERATING COST	16 996	19 651	23 590	21 806	24 686	21 001	
$/ton	3.40	3.93	4.72	4.36	4.94	4.20	
WORKING CAPITAL	65 924	66 511	67 550	66 831	67 251	66 754	

ECONOMIC COMPARISON

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED

100 % MINAS FEED RUN (5MMT/YEAR)

UNITS \ CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack./cok.	7 Visb./Th Cok.
SALES							
Local	306 526	397 984	478 585	471 019	524 905	459 235	
Export	249 660	173 250	114 925	109 260	63 130	116 875	
T O T A L	556 186	571 234	593 510	580 279	588 035	576 110	
RAW MATERIALS							
Local	513 000	513 000	513 000	513 000	513 000	513 000	
Export	-	-	-	-	-	-	
T O T A L	513 000	513 000	513 000	513 000	513 000	513 000	
OPERATING COST	16 996	19 651	23 598	21 806	24 606	21 001	
GROSS CASH FLOW	26 190	38 583	56 912	45 473	50 349	42 109	
TOTAL INVESTMENT	349 045	424 835	544 810	404 000	502 040	454 500	
PAY OUT (YEARS)	13.4	11.0	9.6	10.6	11.6	10.8	
Δ PO (1)	-	-	+2.3	-	-		
Δ PO (2)	-	-	-	-	-		
DEPRECIATION	23 323	28 322	36 321	32 272	30 802	30 305	

RUNNING PROCESS UNITS CARACTIES AS PER % OF DESIGN
DESIGN BASIS : MINAS/ARABIAN 50/50 % FEED
100 % ARABIAN CRUDE FEED RUN
5,0 MM T/YEAR OF CRUDE

PROCESS UNITS \ REFINING SCHEME	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. ATMOSPHERIC CRUDE DISTILLATION	100	100		100		
. NAPHTA STABILIZATION AND SPLITTING	83	91		91		
. CATALYTIC REFORMER	100	100		100		
. KEROSENE HYDROTREATER	100	100		100		
. LIGHT GASOLINE SR MEROX	100	100		100		
. GAS PLANT	100	97		100		
. LPG MEROX	82	100		112		
. DEA TREATER	100	95		100		
				126		
. VACUUM DISTILLATION	-	92		92		
. CATALYTIC CRACKER (FCC)	-	100		-		
. FCC GASOLINE MEROX	-	100		-		
. HYDROCRAKER	-	-		100		
. THERM. CRACKER/ COKER	-	-		-		
. DELAYED COKER	-	-		-		
. COKER HYDROTREATER	-	-		-		
. CALCINER	-	-		-		
. STEAM REFORMER (NM^3/H PURE H_2 BASED ON REFORMING OFF-GAS)	-	-		100		

TOTAL REFINERY PRODUCTION
DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
100 % ARABIAN CRUDE FEED RUN
5,0 MM T/YEAR OF CRUDE

PRODUCTS (10^3 T/YEAR)	MARKET STRUCTURE	1 HYDROSKIM.	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. LPG	60	45	60		60		
. GASOLINE	770	770	770		770		
. JET FUEL	195	195	195		195		
. KEROSENE	490	245	245		271		
. DIESEL OIL	1835	1325	1550		1835		
. FUEL OIL PRODUCTION		1436	1428		1518		
. REFINERY FUEL OIL CONSUMPTION		36	28		118		
. NET FUEL OIL PRODUCTION	1400	1400	1400		1400		
. EXCESS PRODUCTS	-	881	602,5		251		
- GASOLINE		-	107,5		132		
- ATMOSPHERIC RESIDUUM		881	495		119		
- VACUUM RESIDUUM		-	-		-		
- CALCINED COKE		-	-		-		
- FUEL GAS		-	-		-		
. LOSSES	250	-	17		10		
- FCC COKE			17		-		
- CALCINER			-		-		
- STEAM REFORMER			-		10		
. TOTAL REFINERY NET PRODUCTS (% NET PRODUCTS/CRUDE FEED)	4750 (95)	3980 (80)	4220 (84)		4531 (91)		
. TOTAL REFINERY PRODUCTS (% NET PROD/TOTAL PROD.)	4750 (100)	4861 (82)	4822,5 (87)		4782 (95)		

UTILITY BALANCES

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED

100 % ARABIAN CRUDE FEED RUN

5,0 $\overline{MM}$ T/YEAR CRUDE

U T I L I T I E S	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING
. WATER/STEAM						
-DESIGN CAPACITIES OF . BOILERS (T/H)	3 X 30	3 X 40		3 X 35		
-DESIGN CAPACITIES OF . DEMINERALIZATION/ BFW (T/H)	100	150		150		
-DESIGN CAPACITIES OF . COOLING TOWER (M^3/H)	2500	3500		3600		
- WATER NET CONSUMPTION (M^3/H) (MAXIMUM)	210	300		310		
. ELECTRIC POWER (KWH/H)						
- PROCESS UNITS CONSUMPTION	4610	5935		10660		
- TOTAL REFINERY CONSUMPTION	9200	11230		16155		
. FUEL						
- TOTAL FUEL FIRED ($\overline{MM}$ KCAL/H)	174	200		260		
- FUEL OIL CONSUMPTION (10^3 T/YEAR)	29	28		110		

OPERATING COST

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED

100 % ARABIAN LIGHT FEED RUN

CASES / UNITS 10³US$	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
OPERATING COST							
Variable charges							
. Utility (power, water)	2 292	2 815		4 000			
. Catalysts and chemicals	325	760		805			
TOTAL	2 617	3 575		4 805			
Fixed charges							
. Labour	1 500	1 690		1 690			
. Technical assistance	300	340		340			
. Maintenance material	3 800	4 630		5 245			
. Insurance	1 910	2 320		2 620			
. Overhead	540	610		610			
. Land rent	50	50		50			
. Interest on working capital	6 505	6 591		6 666			
TOTAL	14 605	16 231		17 221			
TOTAL OPERATING COST	17 222	19 806		22 026			
$/ton	3.44	3.96		4.41			
WORKING CAPITAL	65 052	65 906		66 666			

ECONOMIC COMPARISON

DESIGN BASIS : MINAS/ARABIAN LIGHT 50/50 % FEED
100 % ARABIAN FEED RUN

CASES / UNITS 10^3US$	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
SALES							
Local	513 745	546 235		500 420			
Export	59 027	46 495		24 341			
TOTAL	572 772	592 730		612 769			
RAW MATERIALS							
Local	-	-		-			
Export	494 000	494 000		494 000			
TOTAL	494 000	494 000		494 000			
OPERATING COST	17 222	19 806		22 026			
GROSS CASH FLOW	61 550	78 924		96 743			
TOTAL INVESTMENT	349 045	424 035		404 000			
PAY OUT (years)	5.6	5.3		5.0			
Δ PO (1)	+ 0.6	+ 0.4		+ 0.2			
Δ PO (2)	+ 1.4	+ 0.7		+ 0.3			
DEPRECIATION	23 323	28 322		32 272			
TAX BASIS	38 227	50 602		64 471			
TAX (40 %)	15 291	20 241		25 788			
A.T. CASH FLOW	46 259	58 683		70 955			
PAY OUT (Years) (A.T.)	7.5	7.2		6.9			

PROCESS UNITS DESIGN CAPACITIES
DESIGN BASIS : MINAS CRUDE 100 % FEED
5.0 MM T/YEAR OF CRUDE

REFINING SCHEME / PROCESS UNITS	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING	7 VB/TC
. ATMOSPHERIC CRUDE DISTILLATION	5000	5000	5000	5000	5000	5000	5000
. NAPHTA STABILIZATION AND SPLITTING	530	530	419	530	419	419	530
. CATALYTIC REFORMER	320	243	243	480	480	493	393
. GAS PLANT	83	237	391	150	306	277	163
. LPG MEROX	34	85	85	84	85	85	85
. DEA TREATER	49	152	306	66	221	192	100
. VACUUM DISTILLATION	-	1890	1890	2845	2325	-	-
. CATALYTIC CRACKER (FCC)	-	1050	1050	-	-	-	-
. FCC GASOLINE MEROX	-	315	315	-	-	-	-
. HYDROTREATER	-	-	-	1590	1300	-	-
. THERM. CRACKER/COKER	-	-	-	-	-	1000	-
. VISBREAKER/THERM. CRACKER	-	-	-	-	-	-	1595
. VB/TC HYDROTREATER	-	-	-	-		-	430
. DELAYED COKER	-	-	1545	-	1025	-	-
. COKER HYDROTREATER	-	-	858	-	523	1202	-
. CALCINER	-	-	253	-	205	259	-
. STEAM REFORMER (NM^3/H PURE H_2 BASED ON :)	-	-	8400 (NAPHTA)	42000 (REFORMING) (OFF-GAS)	35000 NAPHTA/REFORMING OFF-GAS)	-	-

TOTAL REFINERY PRODUCTION
DESIGN BASIS : MINAS CRUDE 100 % FEED
5.0 MM T/YEAR OF CRUDE

PRODUCTS (10^3 T/YEAR)	MARKET STRUCTURE	1 HYDROSKIM.	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING	7 VB/TC
. LPG	60	20	60	60	60	60	60	60
. GASOLINE	770	429	770	770	752	770	770	522
. JET FUEL	195	195	195	195	195	195	195	195
. KEROSENE	490	245	245	490	490	490	490	245
. DIESEL OIL	1835	1217/1055	1150	1474	1235	1835	1500	1362
. FUEL OIL PRODUCTION		75/237	710	1200	1047	1200	1219	1513
. REFINERY FUEL OIL CONSUMPTION		75	10	0	197	72	119	113
. NET FUEL OIL PRODUCTION	1400	0/162	700	1200	850	1137	1100	1400
. EXCESS PRODUCTS	-	2770	1651	428	545	168	527	1137
- GASOLINE		-	-	180	-	-	-	-
- ATM. RESIDUUM		2770	955	-	-	-	315	1137
- VAC. RESIDUUM		-	696	-	545	-	-	-
- CALCINED COKE		-	-	208	-	168	212	-
- FUEL GAS		-	-	40	-	-	-	-
. LOSSES	250	-	67	117	10	52	47	-
- FCC COKE			67	67	-	-	-	
- CALCINER			-	45	-	37	47	
- STEAM REFORMER			-	5	10	15	-	
. TOTAL REFINERY NET PRODUCTS	4750	2106	3120	4189	4182	4487	4115	3784
(% NET PROD./CRUDE FEED)	(95)	(42)	(62)	(84)	(84)	(90)	(82)	(76)
. TOTAL REFINERY PROD.	4750	4876	4771	4617	4727	4655	4642	4921
(% NET PROD./TOT. PROD)	(100)	(43)	(65)	(90)	(89)	(96)	(89)	(77)

UTILITY BALANCES
DESIGN BASIS : MINAS CRUDE 100 % FEED
5.0 MM T/YEAR OF CRUDE

UTILITIES	1 HYDROSKIM	2 FCC	3 FCC/COKING	4 HCK	5 HCK/COKING	6 TC/COKING	7 VB/TC
. WATER/STEAM							
- DESIGN CAPACITIES OF: . BOILERS (T/H)	3 X 25	3 X 45	3 X 55	3 X 30	3 X 45	3 X 20	3 X 20
. DEMINERALIZATION/BFW (T/H)	80	180	220	180	200	120	100
. COOLING TOWER (M^3/H)	1000	4500	5500	4600	5000	3000	2500
- WATER NET CONSUMPTION (M^3/H) (MAXIMUM)	160	360	450	370	410	250	230
. ELECTRIC POWER (KWH/H)							
- PROCESS UNITS CONSUMPTION	3570	6560	15530	16150	20660	15630	7340
- TOTAL REFINERY CONSUMPTION	8010	11950	21680	21590	26760	20000	10890
. FUEL							
- TOTAL FUEL FIRED (MM KCAL/H)	150	202	328	329	383	306	249
- FUEL OIL CONSUMPTION (10^3 T/YEAR)	75	10	0	197	72	119	113

INVESTMENT CALCULATION

DESIGN BASIS : MINAS 100 % FEED (5MMT/YEAR)

IN THOUSAND US$ 1978

UNITS \ CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
PROCESS UNITS							
Atmospheric crude distillation	20 000	20 000	20 000	20 000	20 000	20 000	20 000
Naphtha stabilization/splitter	3 000	3 000	2 600	3 000	2 600	2 600	3 000
HDS/catalytic reformer	13 200	10 700	10 700	18 000	18 000	18 200	15 500
Kerosene hydrotreater	-	-	-	-	-	-	-
Gas plant	1 700	3 300	4 600	2 650	4 000	3 750	2 800
DEA treater	1 000	1 900	3 000	1 100	2 400	2 200	1 400
LPG sweetening	700	1 200	1 200	1 200	1 200	1 200	1 200
S.R. light gasoline sweet.	-	-	-	-	-	-	-
Vacuum distillation		14 000	14 000	18 600	16 200		
Catalytic cracker (FCC)		36 000	36 000				
FCC gasoline sweetening		3 500	3 500				
Hydrocracker				54 000	47 400		
Thermal cracker/coker						34 700	
Delayed coker			23 950		18 000		
Coker hydrotreater			13 800		9 500	17 750	8 200
Calciner			10 900		9 400	11 000	
Coke handling and storage			12 400		10 700	12 500	
Hydrogen plant			6 400	19 650	17 100	-	
Visbreak/crack. therm.							28 000
TOTAL 1	39 600	93 600	163 050	138 200	175 300	123 900	80 100
UTILITY - OFFSITES							
Utility	11 900	23 100	27 750	18 450	26 250	13 500	13 000
Storage	61 600	60 600	59 200	59 400	59 000	59 400	61 400
General services	16 500	22 300	35 850	30 300	38 500	27 500	21 300
Buildings	15 700	18 700	20 000	18 700	20 000	18 700	18 700
Site preparation	18 800	19 000	24 450	19 000	24 450	19 000	19 000
TOTAL 2	124 500	143 700	167 250	145 850	168 200	138 100	133 400

INVESTMENT CALCULATION (CONTINUED)

IN THOUSAND US$ 1978

UNITS \ CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
PROCESS UNITS	39 600	93 600	163 050	138 200	175 300	123 900	80 100
UTILITY - OFFSITES	124 500	143 700	167 250	145 850	168 200	138 100	133 400
ERECTED COST - EUROPE BASIS	164 100	237 300	330 300	284 050	343 500	262 000	213 500
TOTAL COST - EUROPE (1.15)	188 700	272 900	379 800	326 700	395 000	301 300	245 500
TOTAL COST - VIETNAM (1.45)	273 600	395 700	550 800	473 600	572 800	436 900	356 000
Spare parts	6 570	9 500	13 220	11 370	13 750	10 500	8 550
Catalysts and chemicals	500	500	900	3 490	3 160	1 120	800
Royalties	500	2 110	3 350	6 020	5 770	1 490	1 060
Preoperating and start up expenses	19 150	27 700	38 560	33 150	40 100	30 500	24 900
TOTAL INVESTMENT (excluding financial charges)	300 400	435 590	606 910	527 630	635 580	480 590	391 310
WORKING CAPITAL	65 909	66 907	67 954	68 136	68 319	67 665	66 734

OPERATING COST

DESIGN BASIS : MINAS 100 % FEED (5MMT/YEAR)

UNITS 10³US$ / CASES	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
OPERATING COST							
Variable charges							
. Utility (power, water)	1 986	3 012	5 383	5 330	6 586	5 092	2 730
. Catalysts and chemicals	217	1 090	1 270	1 200	1 100	420	325
TOTAL	2 203	4 102	6 653	6 530	7 686	5 512	3 055
Fixed charges							
. Labour	1 500	1 690	1 870	1 690	1 870	1 690	1 690
. Technical assistance	300	340	370	340	370	340	340
. Maintenance material	3 300	4 750	6 600	5 700	6 875	5 250	4 275
. Insurance	1 640	2 370	3 300	2 840	3 440	2 620	2 140
. Overhead	540	610	670	610	670	610	610
. Land rent	50	50	50	50	50	50	50
. Interest on working capital	6 591	6 699	6 795	6 814	6 832	6 766	6 673
TOTAL	13 921	16 509	19 655	18 044	20 107	17 326	15 778
TOTAL OPERATING COST	16 124	20 611	26 308	24 574	27 793	22 838	18 833
$/ton	3.22	4.12	5.26	4.91	5.56	4.57	3.77
WORKING CAPITAL							

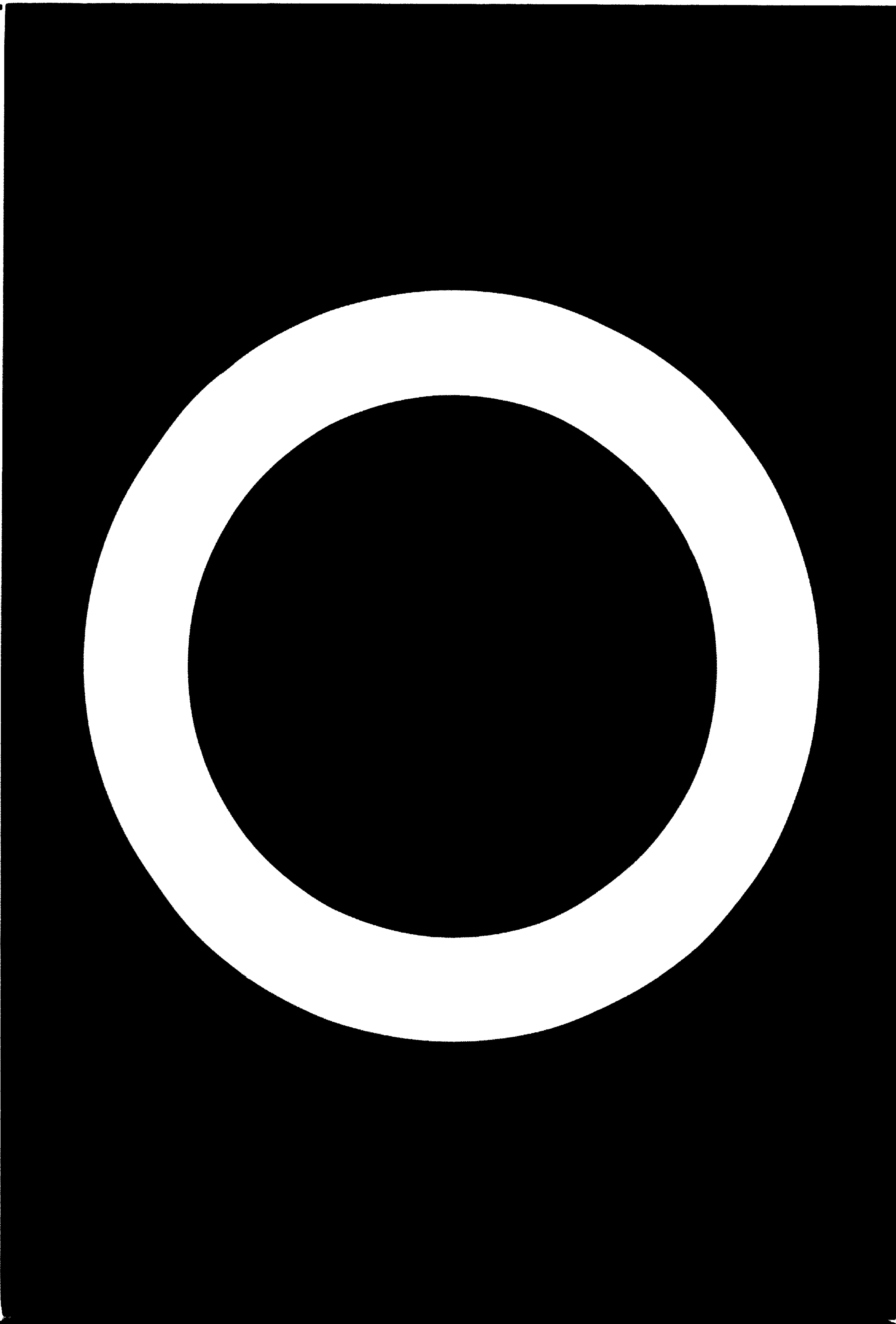
ECONOMIC COMPARISON

DESIGN BASIS : MINAS 100 % FEED (5MMT/YEAR)

CASES / UNITS 10^3 US$	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
SALES							
Local	306 526	431 335	553 610	568 547	596 864	548 420	474 727
Export	249 300	148 690	46 320	43 600	16 800	49 550	102 330
TOTAL	555 826	580 025	599 930	612 147	613 664	597 970	577 057
RAW MATERIALS							
Local	513 000	513 000	513 000	513 000	513 000	513 000	513 000
Imported	-	-	-	-	-	-	-
TOTAL	513 000	513 000	513 000	513 000	513 000	513 000	513 000
OPERATING COST	16 134	20 611	26 308	24 574	27 793	22 838	18 833
GROSS CASH FLOW	26 692	46 414	60 622	74 573	72 871	62 132	45 224
TOTAL INVESTMENT	300 400	435 590	606 910	527 630	635 580	480 590	391 310
PAY OUT (Years)	11.3	9.4	10.0	7.1	8.7	7.7	8.7
Δ PO (1)	-	+ 4.1	+ 0.7	+ 0.4	+ 0.2	+ 0.7	+ 2.7
Δ PO (2)	-	-	-	-	+ 0.4	+ 1.5	-
DEPRECIATION				35 175		32 039	
TAX BASIS				39 398		30 093	
TAX (40 %)				15 759		12 037	
A.T. CASH FLOW				58 814		50 094	
PAY OUT (Years) (A.T.)	> 10	> 10	> 10	9.0	> 10	9.6	> 10

(1) *export sales - 10 %*

(2) *export sales - 10 % and coke + naphtha - 20 %*



4. RESULTS

The most significant results of the technico-economic comparisons are shown in table .

From these results can be seen :

- The effects of the quality and costs of the crude oils processed
- The refining schemes best suited to the market, from a technical and economic viewpoint.

- Local crude oil does not correspond to demand ; hence, processing solely local crude would mean heavy investment if demand is to be matched.

- Processing -in part at least- of an imported crude oil of typical Persian Gulf grade offers a means of reducing investments (though not in the case of the simple scheme) and considerably increasing quantities supplied to the domestic market.

- Local crude oil with its low sulphur content cannot be used to best advantage on the Vietnamese domestic market, which makes it too expensive compared with imported crude oil under the international market and transport conditions retained for this study.

- The simple scheme (n°1 : hydroskimming) involves the least investment ; however, it is much more suitable for imported crude (80 % market satisfaction) than for local crude (only 42 %) and could not be considered unless a high proportion of imported crude is to be processed.

- The schemes involving coking (n°6 : coking/thermal cracking) and hydrocracking (n°4) satisfy the market fairly well and at the same time do not require too high investment ; however, extra investment over the simple scheme amounts to more than 100 million dollars.

- The coking scheme (N°6) is less costly than the hydro-cracking scheme (n°4), but product quality is less certain. In addition this scheme requires at least partial supplies of local crude oil so that coke produced can be valorized.

- The hydrocracking-coking scheme (n°5) is both the best suited to the market and the most costly. As in the case of scheme n°6, a partial supply at least of local crude would be necessary.

- The schemes comprising a catalytic cracking unit (n° 2 and n° 3) are not particularly attractive, unless the gasoline (or naphtha) market proves larger than expected.

- Most of the proposed schemes will lead to surpluses of some products - fuel oil, coke, naphtha -. Valorisation of such surpluses on the export market considerably affects profitability, particularly in the case of schemes involving significant surpluses, i.e. n°1 (hydroskimming) and n°2 (catalytic cracking).

MAIN ECONOMIC RESULTS

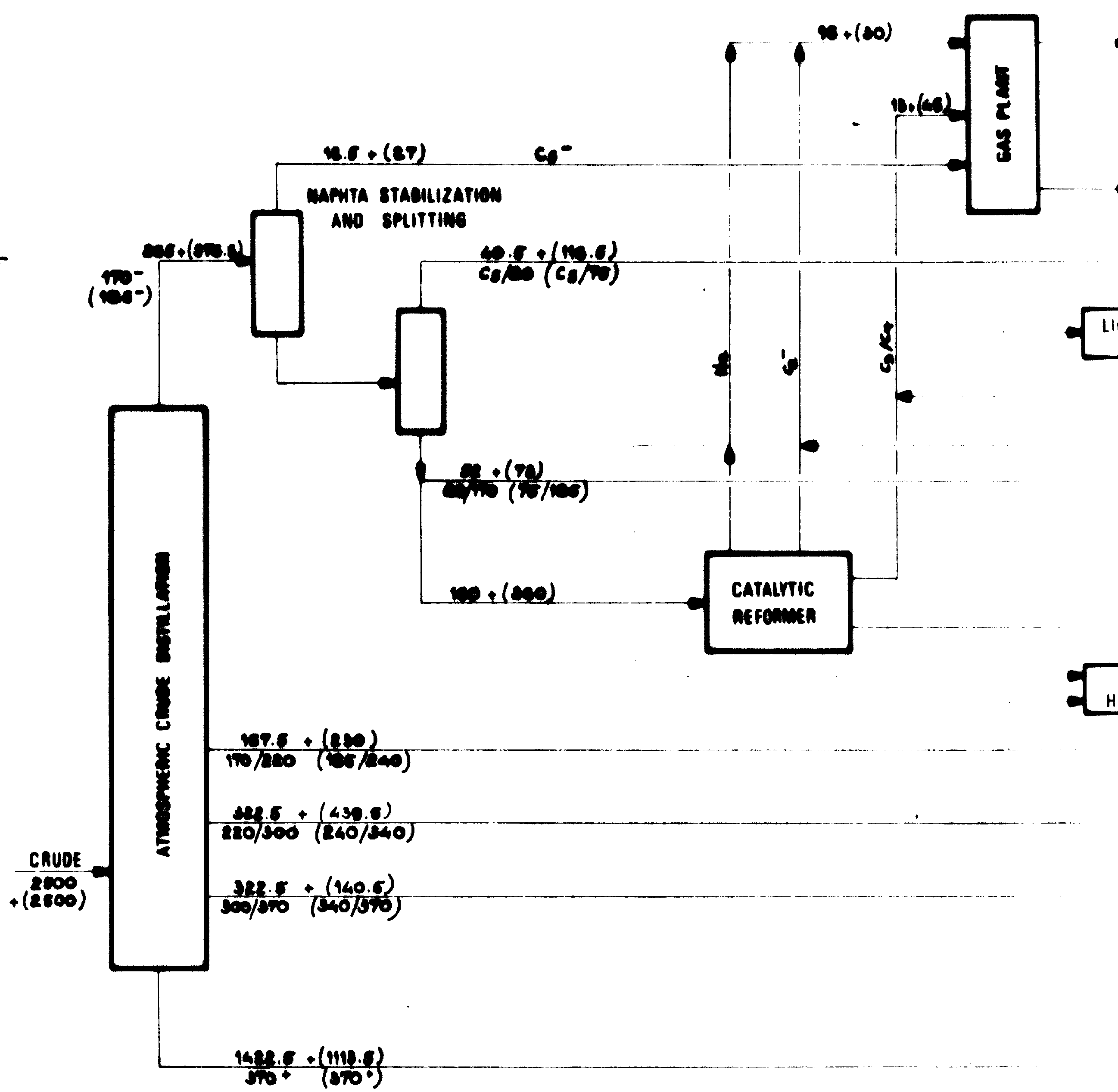
IN THOUSAND $ 1978

CASES / UNITS	1 Hydro-skimming	2 Catalytic cracking	3 Cat.Crack. cok.	4 Hydro-cracking	5 Hydrocra./ cok.	6 Therm.Crack. cok.	7 Visb./Th Cok.
DESIGN 50/50 MENAS/ARABIAN LIGHT							
INVESTMENT (rounded)	360 000	425 000	545 000	404 000	582 000	455 000	
PAY OUT (years)							
. Feed 50/50 local/imported	6.4	6.4	6.9	5.9	6.5	5.9	
Δ export - 10 %	+ 1.0	+ 0.7	+ 0.4	+ 0.2	+ 0.1	+ 0.3	
Δ import, crude + 1 %	+ 0.3	+ 0.2	+ 0.2	+ 0.2	+ 0.2	+ 0.2	
Δ investment + 10 %	+ 0.7	+ 0.7	+ 0.7	+ 0.0	+ 0.6	+ 0.6	
local products/crude feed	74	81	87	90	92	87	
. Feed 100 local	13.4	11.0	9.6	10.6	11.6	10.8	
. Feed 100 imported	5.6	5.3		5.0			
DESIGN 100 MENAS							
INVESTMENT (rounded)	300 000	436 000	607 000	520 000	636 000	401 000	301 000
PAY OUT (years)							
. Feed 100 local	11.3	9.4	10.0	7.1	8.7	7.7	8.7
Δ export - 10 %	–	+ 4.1	+ 0.7	+ 0.4	+ 0.2	+ 0.7	+ 2.7
Local products/crude feed	42	62	84	84	90	82	76

_ MINAS CRUDE RUN

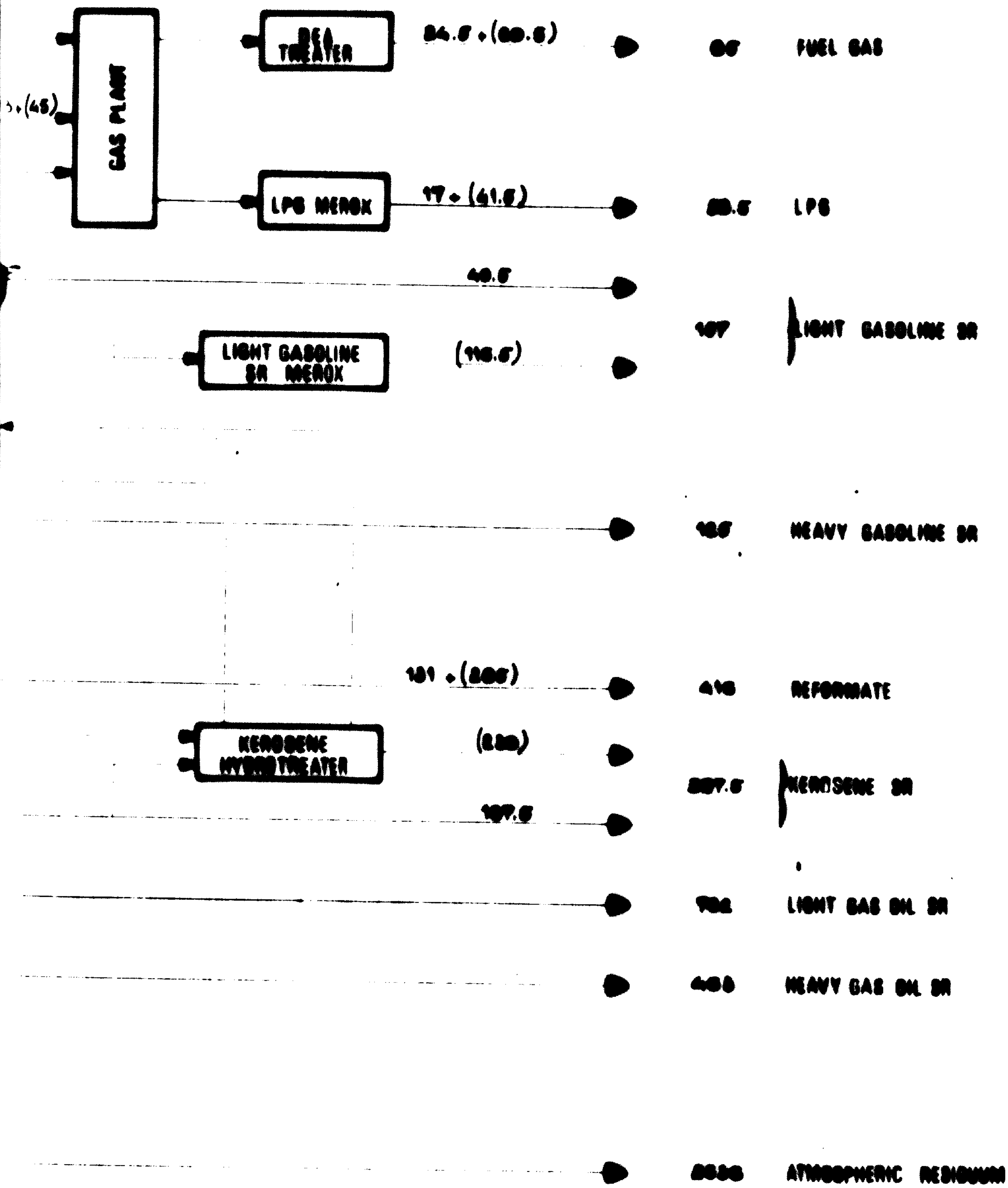
(—) ARABIAN LIGHT CRUDE RUN

MATERIAL BALANCE

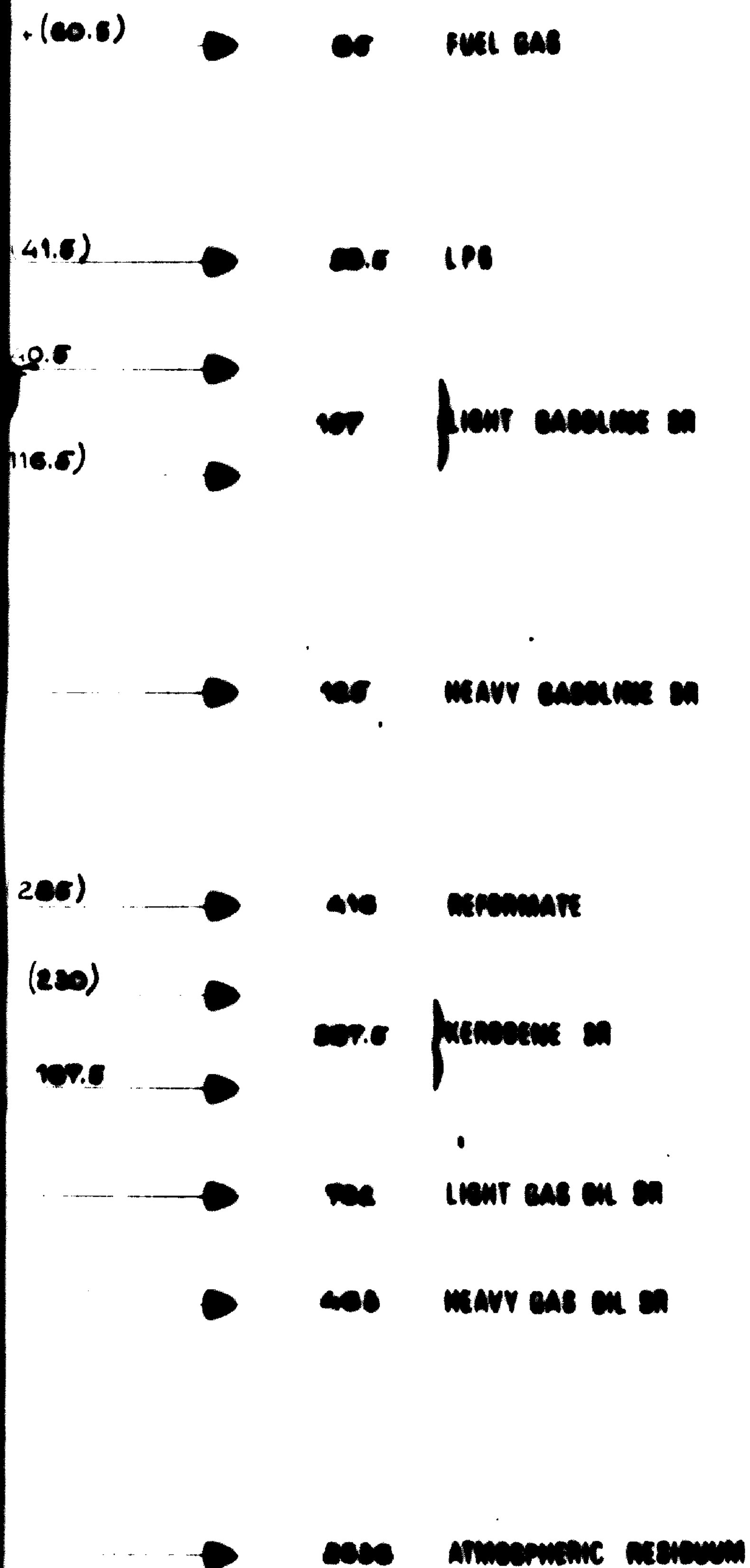


SECTION 1

MATERIAL BALANCE 10^3 T/YEAR



SECTION 2



SECTION 3

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PETROVIETNAM REFINERY

REFINING SCHEME N° 1

MINAS / ARABIAN LIGHT FEED

50/50%

SCALE		REV
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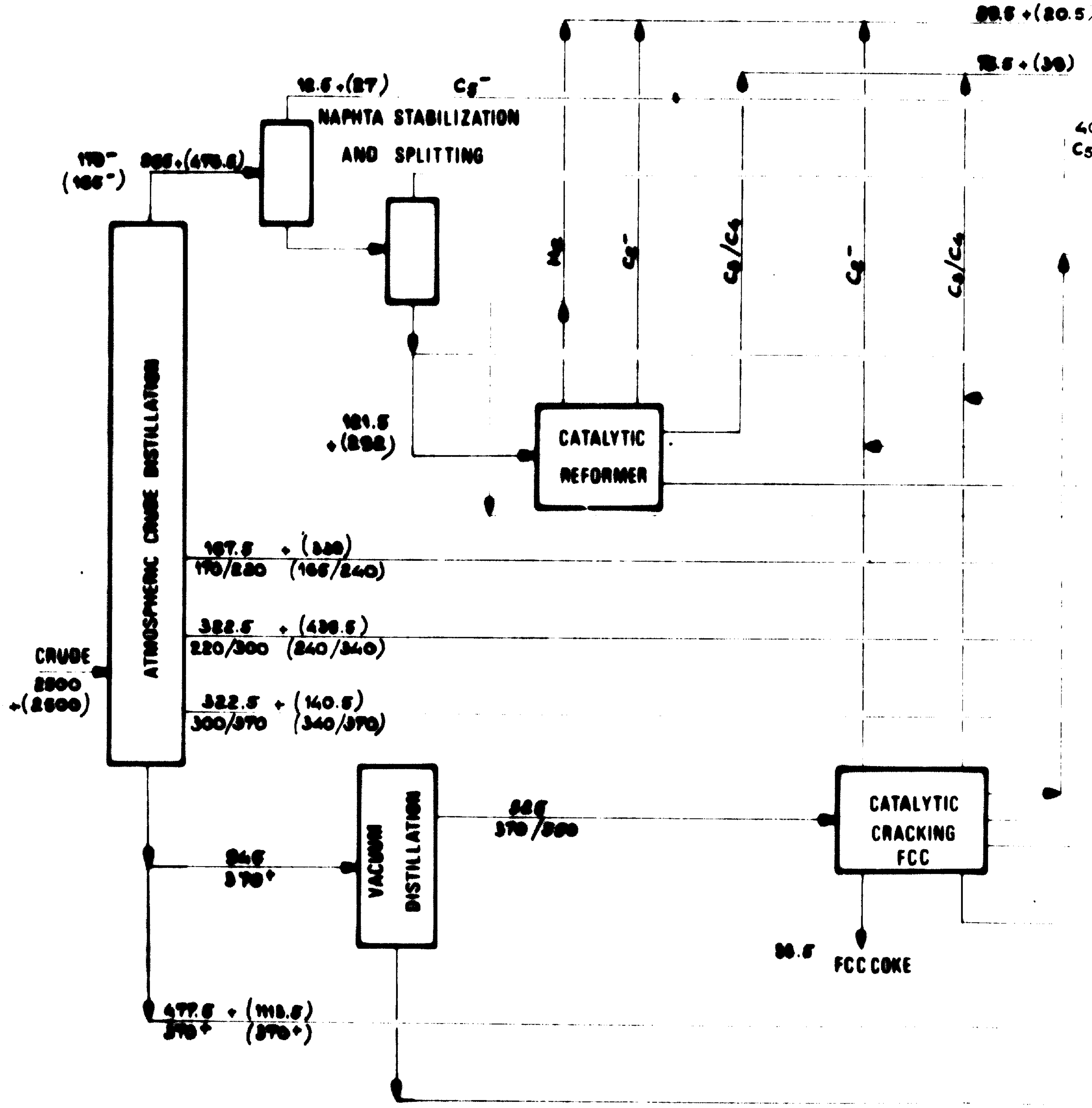
— MINAS CRUDE RUN

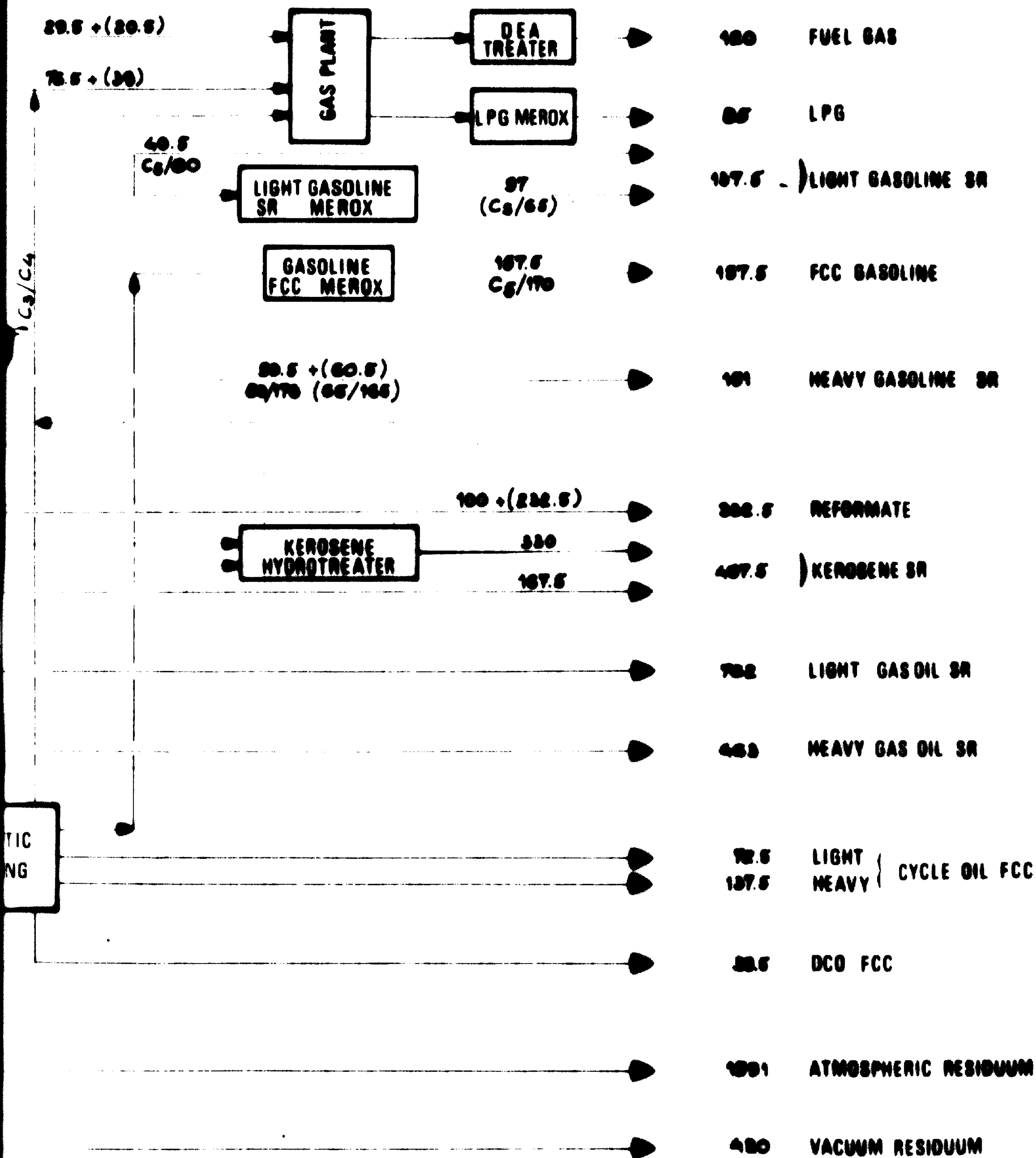
(—) ARABIAN LIGHT CRUDE RUN

MATERIAL BA



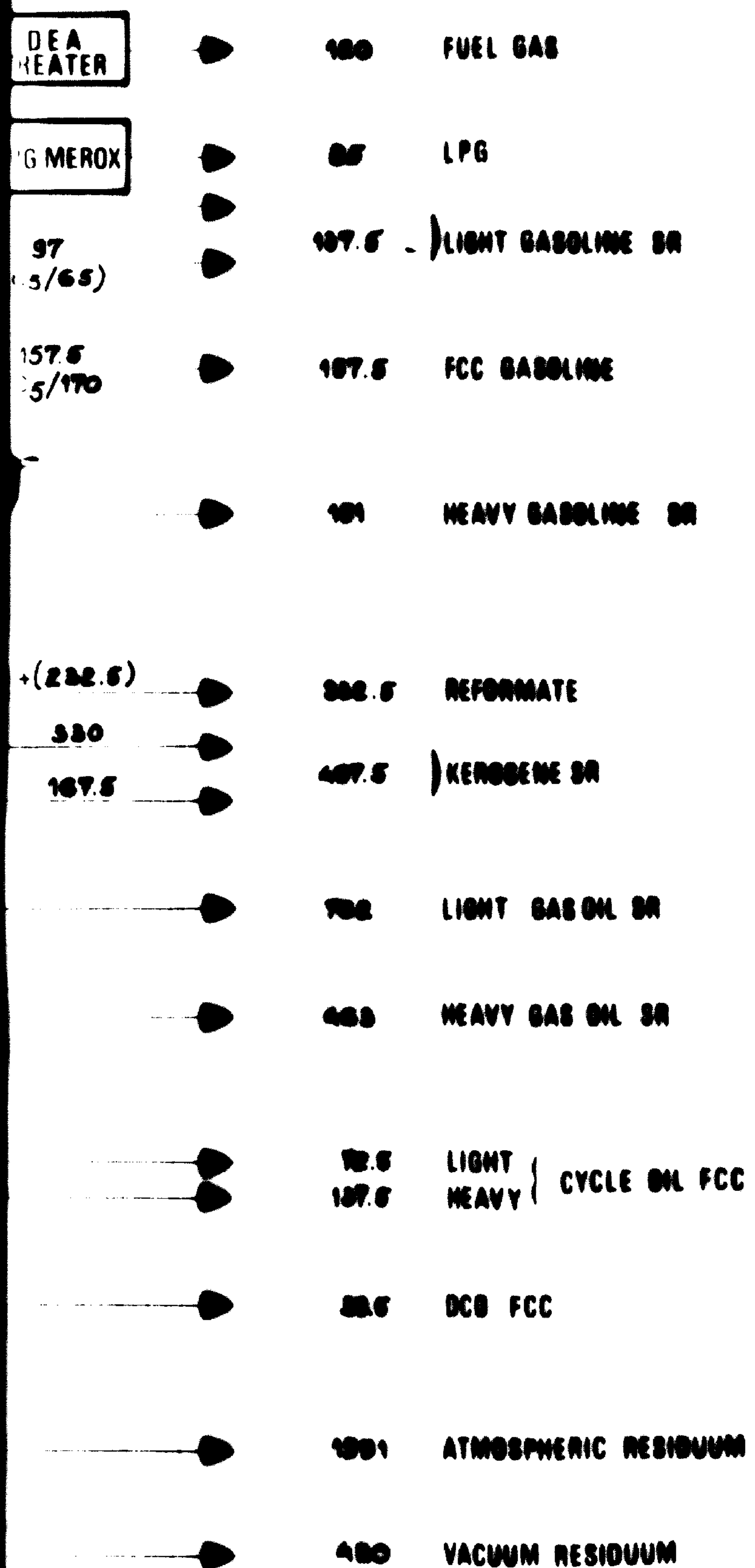
SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

SCALE



SECTION 3

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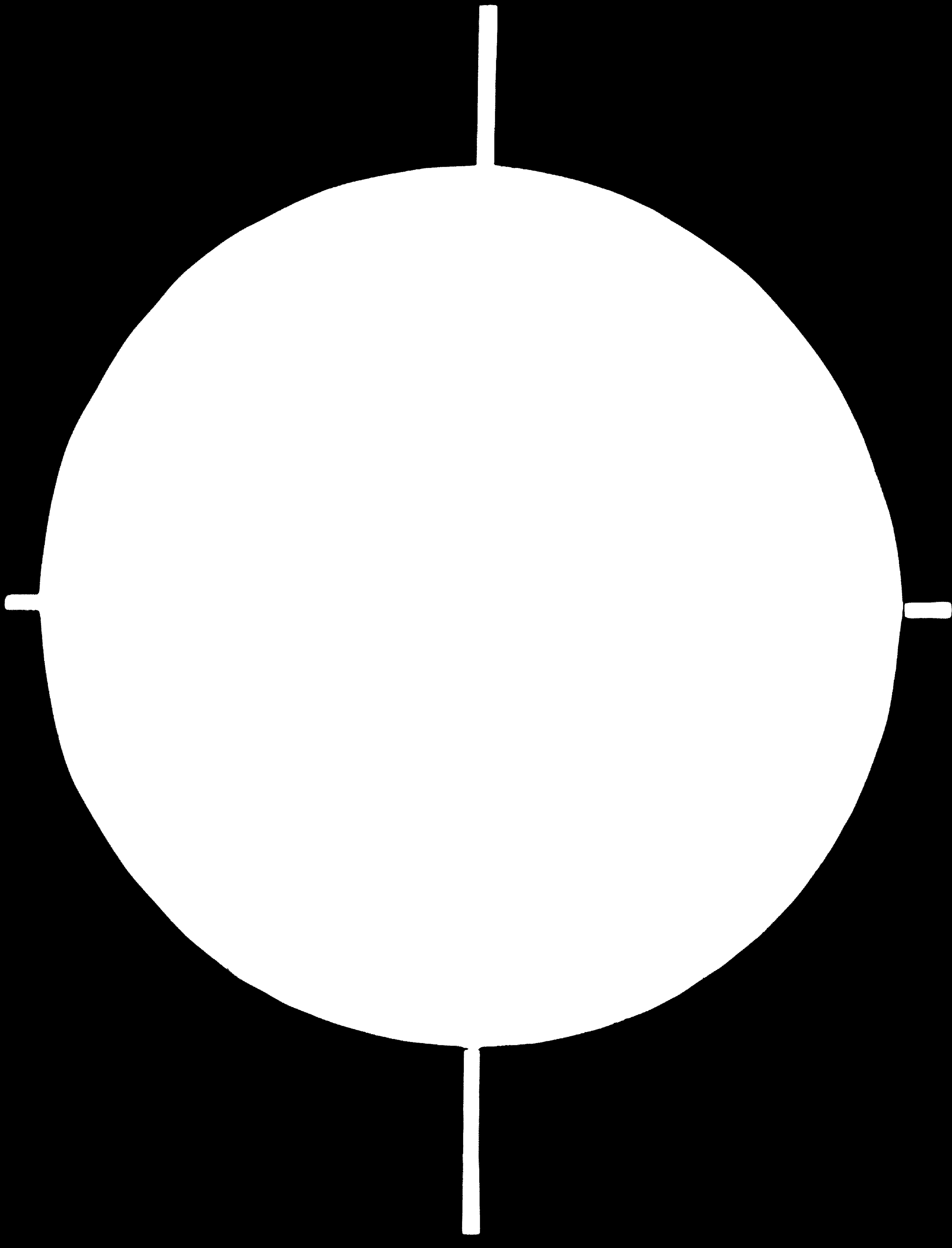
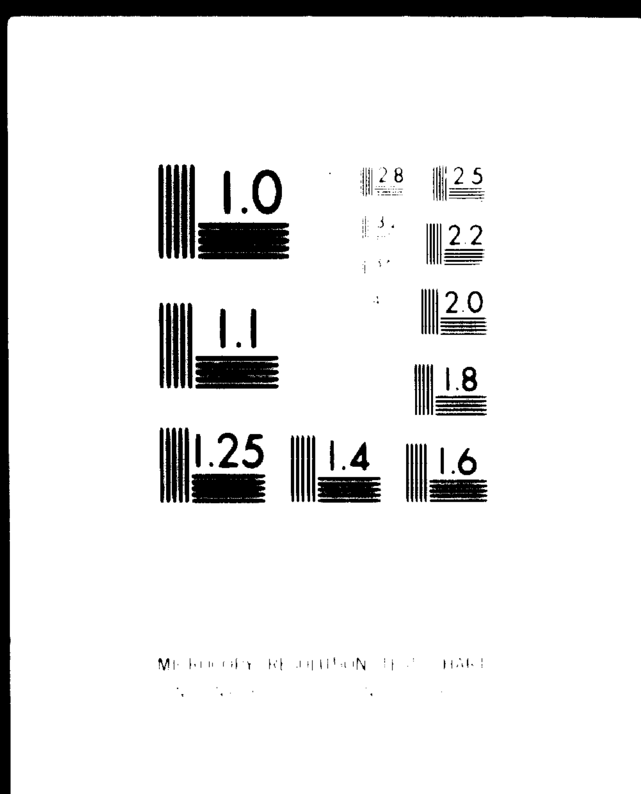
PETROVIETNAM REFINERY
REFINING SCHEME N° 2
MINAS / ARABIAN LIGHT FEED
50/50 %

SCALE
REV
09/78
78060 - A. 102



3 OF 3

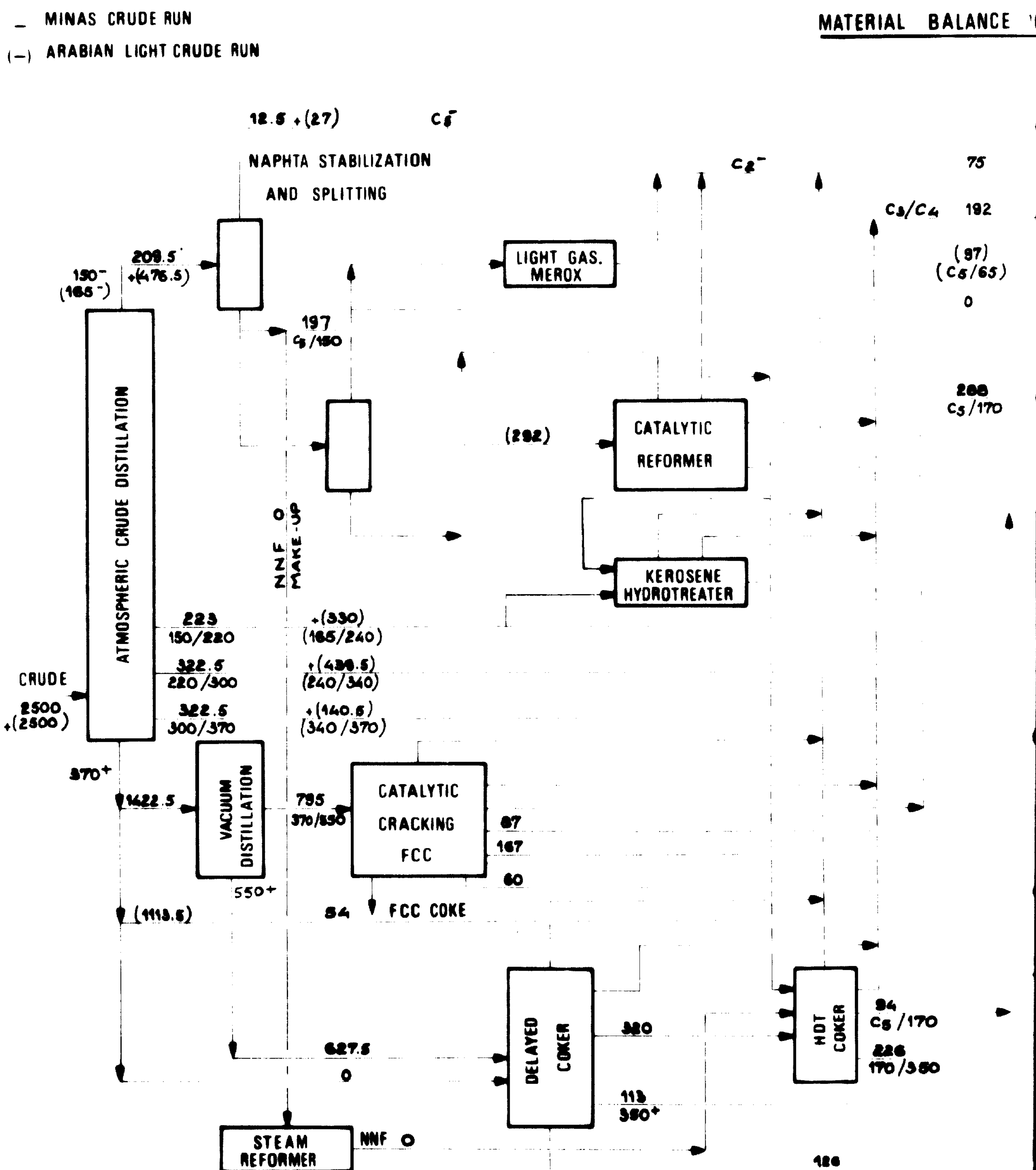
08885



24x

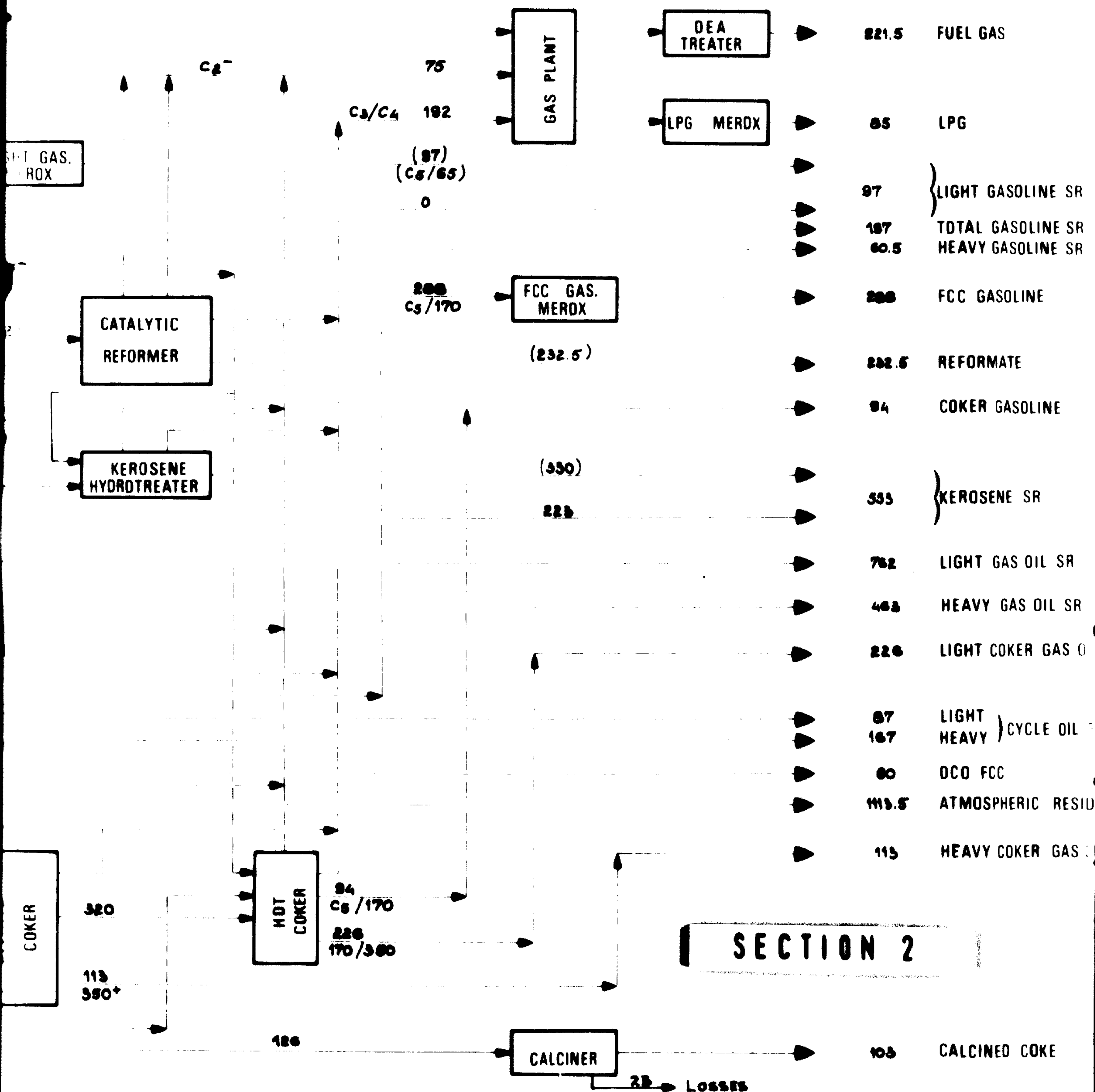
C

MATERIAL BALANCE



SECTION 1

MATERIAL BALANCE 10^3T/YEAR



SECTION 2

DEA TREATER

LPG MEROX

221.5	FUEL GAS
85	LPG
97	LIGHT GASOLINE SR
157	TOTAL GASOLINE SR
60.5	HEAVY GASOLINE SR
[illegible]	FCC GASOLINE
232.5	REFORMATE
94	COKER GASOLINE
555	KEROSENE SR
782	LIGHT GAS OIL SR
468	HEAVY GAS OIL SR
226	LIGHT COKER GAS OIL
87	LIGHT CYCLE OIL FCC
167	HEAVY CYCLE OIL FCC
60	DCO FCC
1113.5	ATMOSPHERIC RESIDUUM
113	HEAVY COKER GAS OIL
105	CALCINED COKE

LOSSES

SECTION 3

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DIVISION DES ÉTUDES INDUSTRIELLES

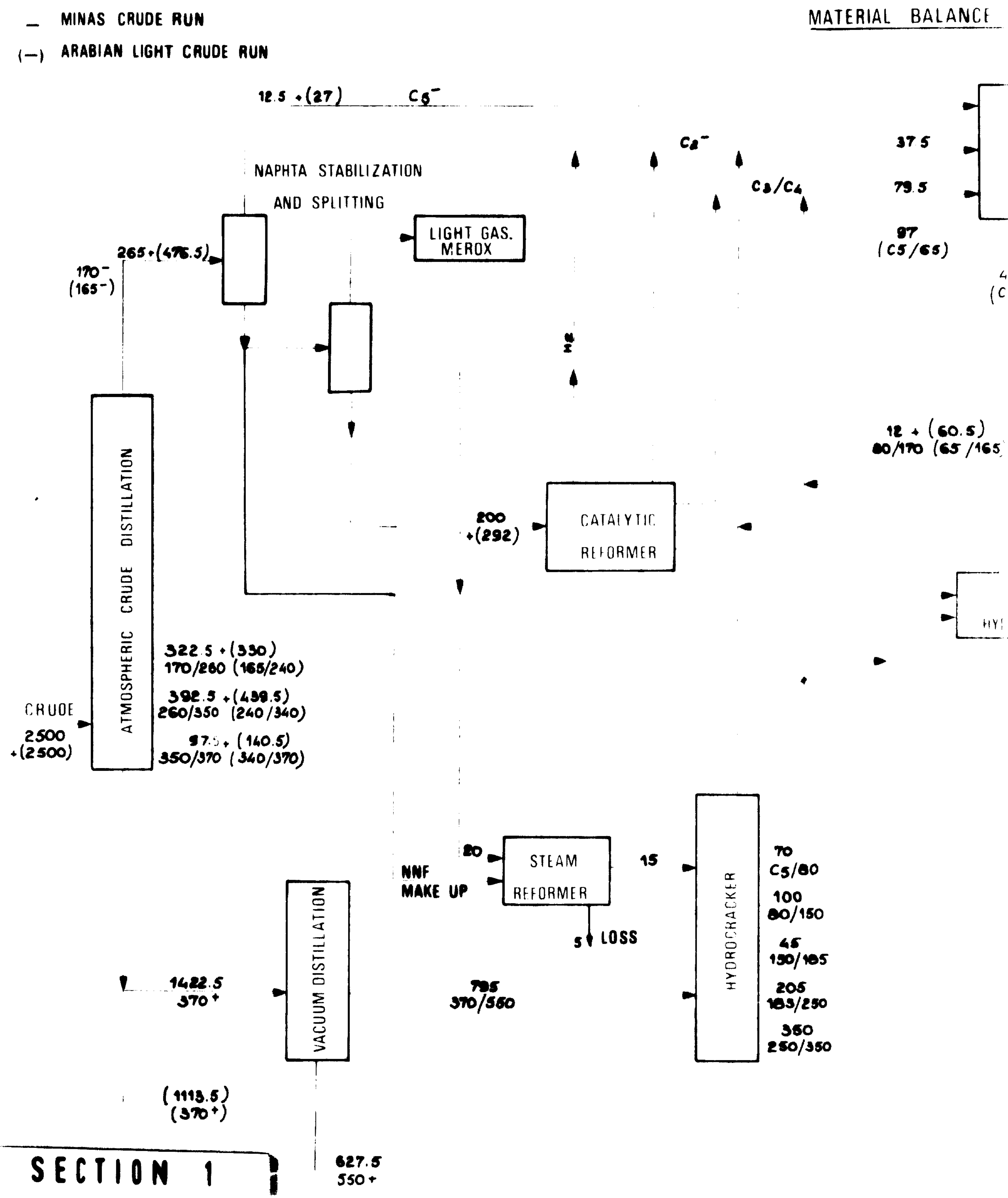
PETROVIETNAM REFINERY

REFINING SCHEME N° 3

MINAS / ARABIAN LIGHT FEED

50/50%

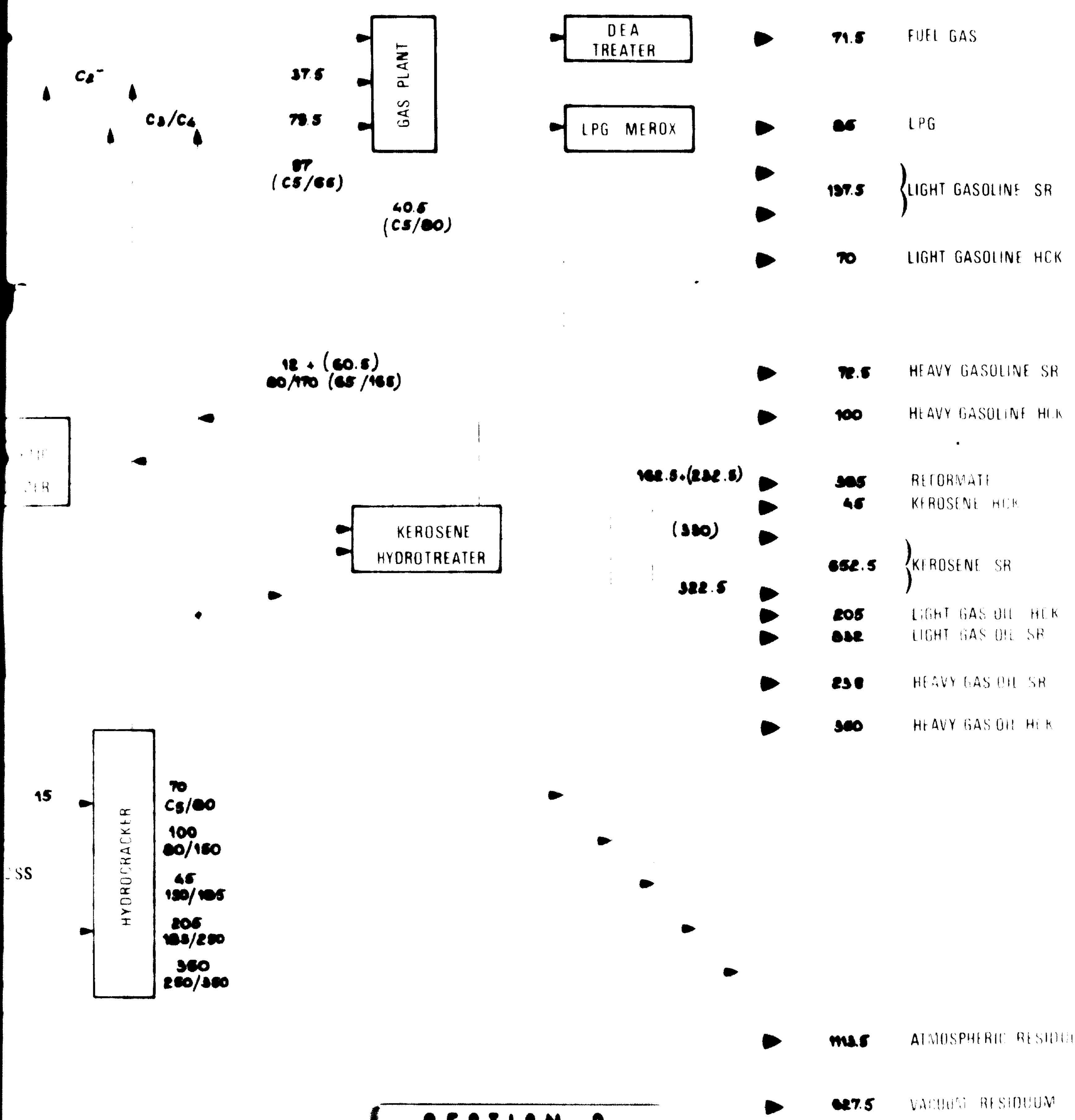
SCALE		REV
	09/78 78060 -A. 103	



— MINAS CRUDE RUN
(—) ARABIAN LIGHT CRUDE RUN
MATERIAL BALANCE
12.5 +(27) C5⁻
NAPHTA STABILIZATION
AND SPLITTING
LIGHT GAS. MEROX
265+(476.5)
170⁻
(165⁻)
C3/C4
37.5
79.5
97
(C5/65)
12 + (60.5)
80/170 (65/165)
200
+(292)
CATALYTIC REFORMER
ATMOSPHERIC CRUDE DISTILLATION
CRUDE
2500
+(2500)
322.5 +(330)
170/260 (165/240)
392.5 +(439.5)
260/350 (240/340)
97.5 + (140.5)
350/370 (340/370)
20
NNF
MAKE UP
STEAM REFORMER
15
5 LOSS
HYDROCRACKER
70
C5/80
100
80/150
45
150/165
205
165/250
360
250/350
795
370/550
1422.5
370⁺
VACUUM DISTILLATION
(1113.5)
(370⁺)
627.5
550+

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



DEA TREATER

LPG MEROX

	71.5	FUEL GAS
	85	LPG
	137.5	LIGHT GASOLINE SR
	70	LIGHT GASOLINE HCK
	72.5	HEAVY GASOLINE SR
	100	HEAVY GASOLINE HCK
162.5+(232.5)	385	REFORMATE
	46	KEROSENE HCK
(330)	652.5	KEROSENE SR
322.5		
	205	LIGHT GAS OIL HCK
	832	LIGHT GAS OIL SR
	238	HEAVY GAS OIL SR
	360	HEAVY GAS OIL HCK
	1113.5	ATMOSPHERIC RESIDUUM
	627.5	VACUUM RESIDUUM

SECTION 3

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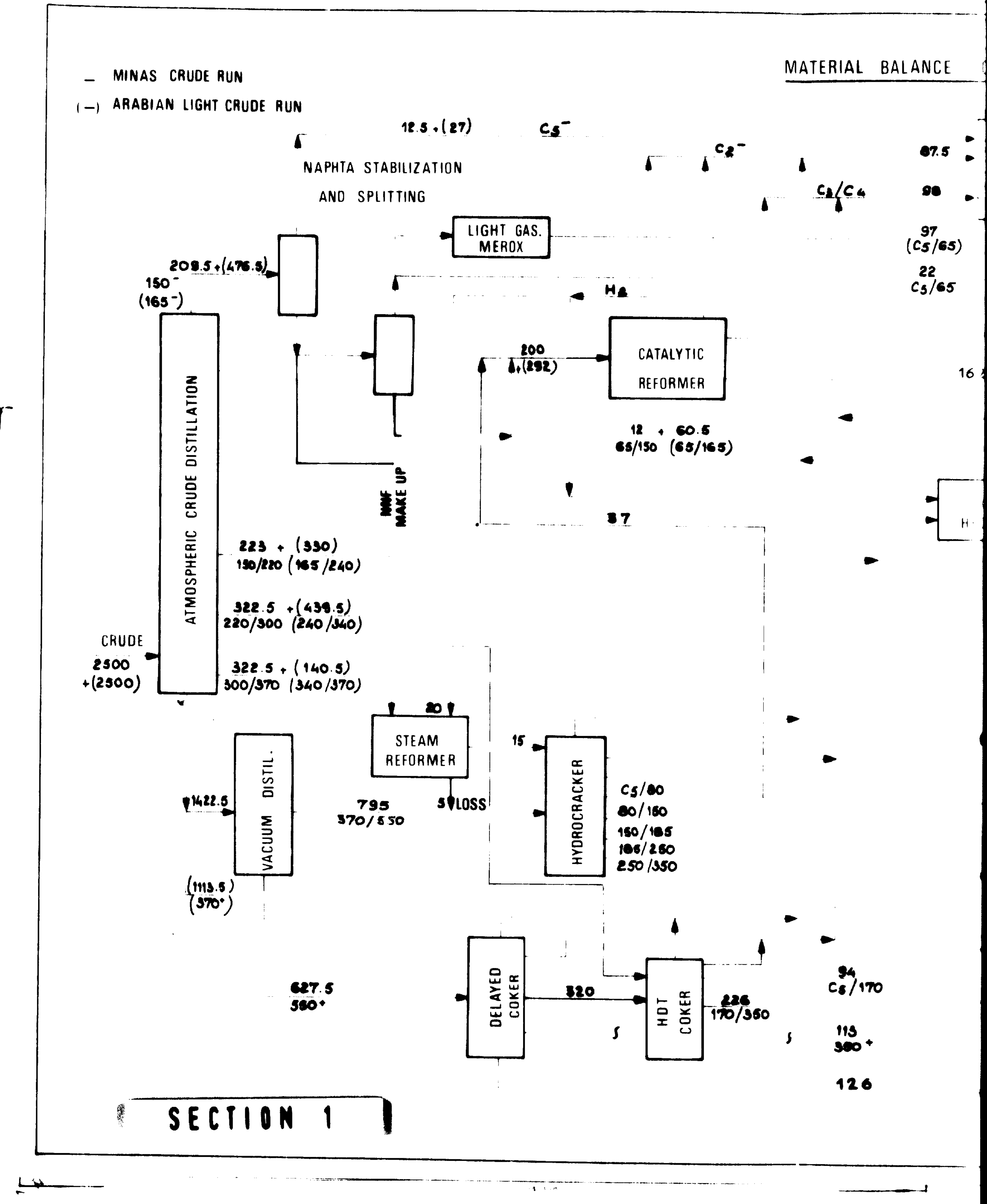
PETROVIETNAM REFINERY

REFINING SCHEME N° 4

MINAS / ARABIAN LIGHT FEED

50/50%

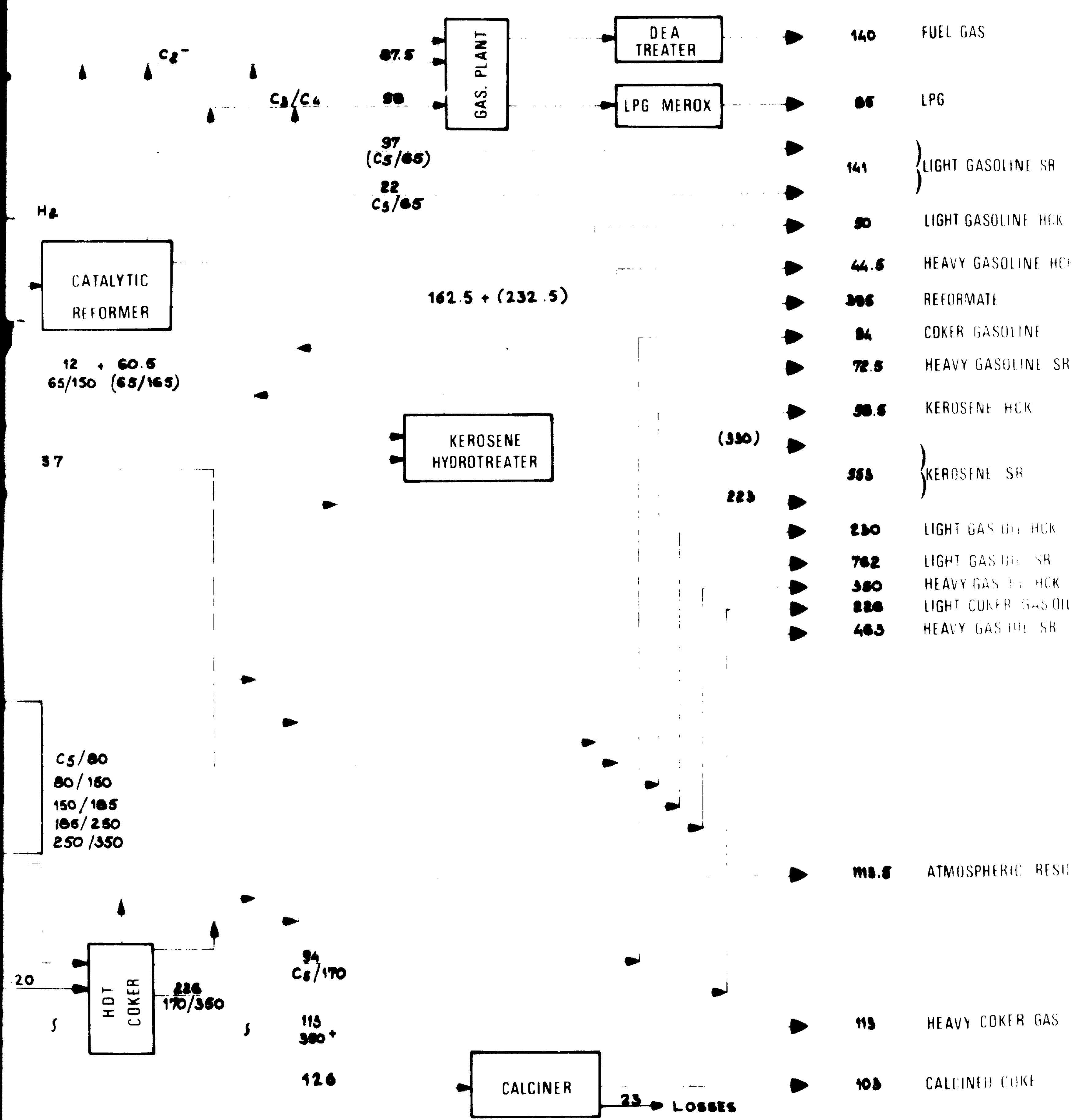
09/78 78060 - A - 104



MATERIAL BALANCE
— MINAS CRUDE RUN
(—) ARABIAN LIGHT CRUDE RUN
12.5 + (27)
C5⁻
NAPHTA STABILIZATION
AND SPLITTING
C2⁻
87.5
C3/C4
98
LIGHT GAS. MEROX
97
(C5/65)
22
C5/65
209.5 + (476.5)
150⁻
(165⁻)
H2
200
+(292)
CATALYTIC REFORMER
16
12 + 60.5
65/150 (65/165)
MAKE UP
37
ATMOSPHERIC CRUDE DISTILLATION
223 + (330)
150/220 (165/240)
322.5 + (439.5)
220/300 (240/340)
CRUDE
2500
+(2500)
322.5 + (140.5)
300/370 (340/370)
20
STEAM REFORMER
15
HYDROCRACKER
1422.5
VACUUM DISTIL.
795
370/550
5 LOSS
C5/80
80/150
150/185
185/250
250/350
(1113.5)
(370⁺)
627.5
550⁺
DELAYED COKER
320
HDT COKER
226
170/350
94
C5/170
113
350⁺
126

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

DEA TREATER

PG MEROX

	140	FUEL GAS
	85	LPG
	141	LIGHT GASOLINE SR
	50	LIGHT GASOLINE HCK
	44.5	HEAVY GASOLINE HCK
	305	REFORMATE
	84	COKER GASOLINE
	72.5	HEAVY GASOLINE SR
	58.5	KEROSENE HCK
(330) / 223	553	KEROSENE SR
	230	LIGHT GAS OIL HCK
	762	LIGHT GAS OIL SR
	380	HEAVY GAS OIL HCK
	228	LIGHT COKER GAS OIL
	463	HEAVY GAS OIL SR
	1118.5	ATMOSPHERIC RESIDUUM
	113	HEAVY COKER GAS OIL
	103	CALCINED COKE
3		LOSSES

SECTION 3

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PETROVIETNAM REFINERY

REFINING SCHEME N° 5

MINAS / ARABIAN LIGHT FEED

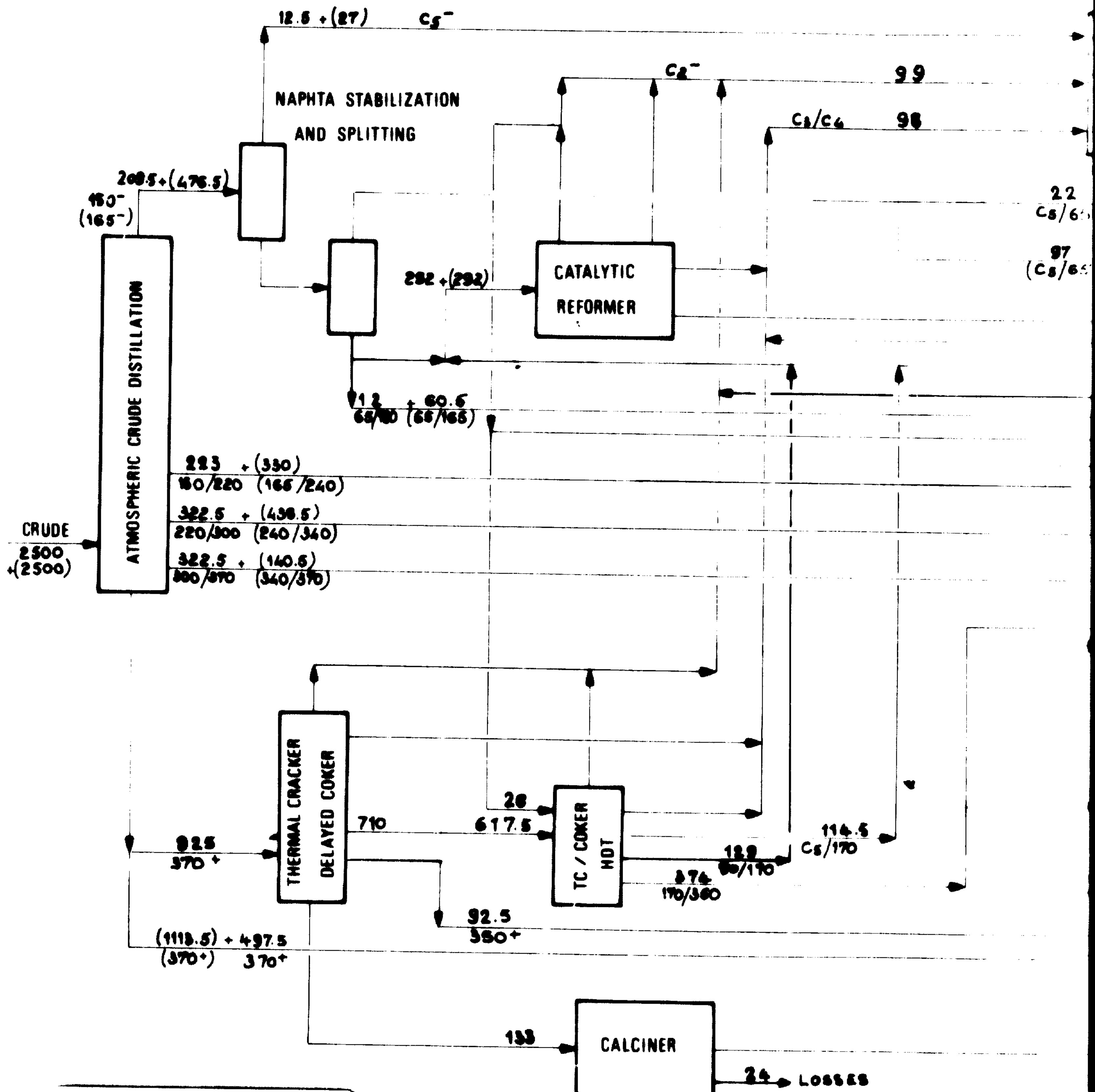
50 / 50%

09/78 78060 - A - 105

_ MINAS CRUDE RUN

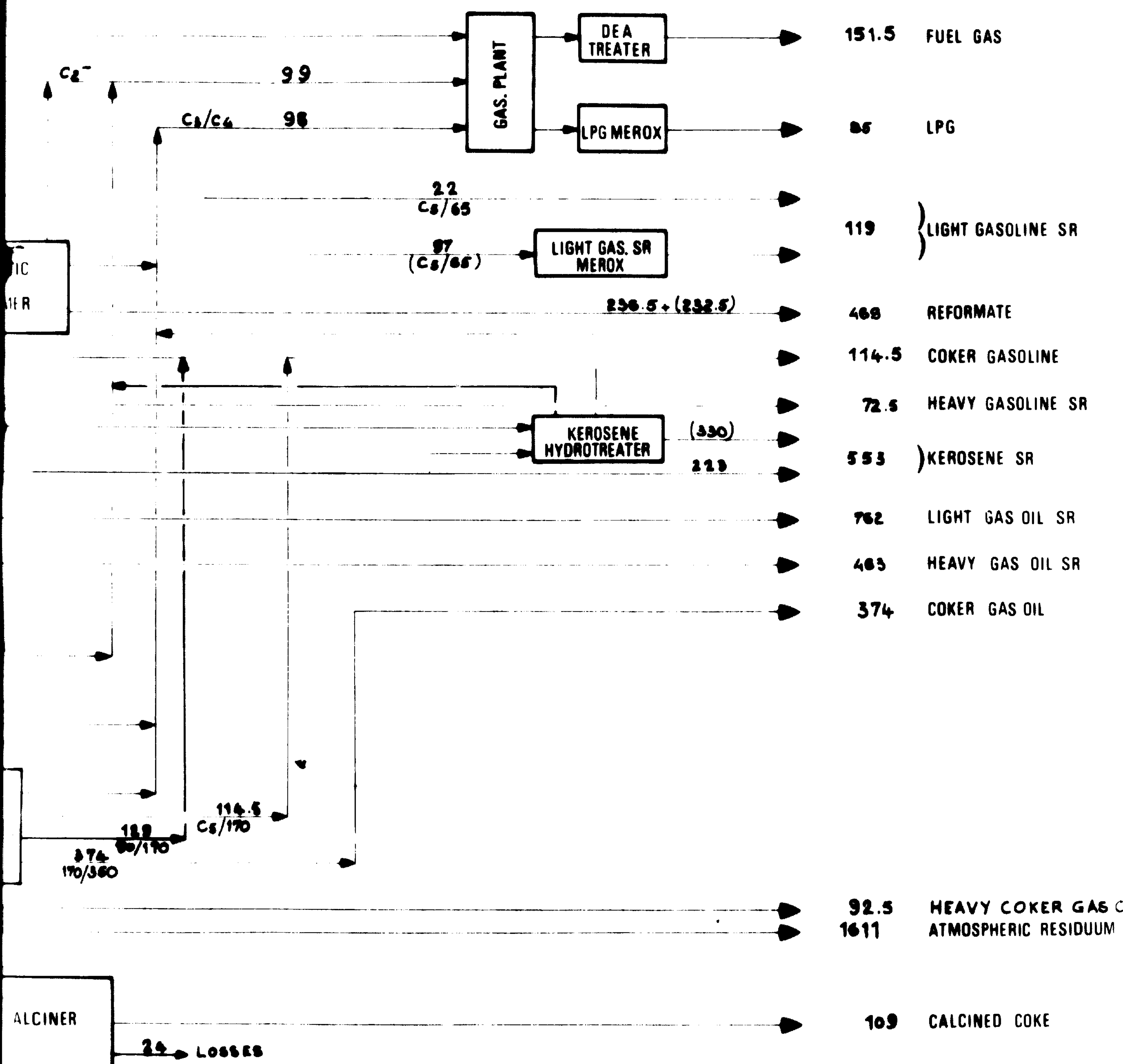
(_) ARABIAN LIGHT CRUDE RUN

MATERIAL BALANCE 10^3 .



SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

5 + (232.5)

(330)
223

151.5 FUEL GAS

85 LPG

119 LIGHT GASOLINE SR

468 REFORMATE

114.5 COKER GASOLINE

72.5 HEAVY GASOLINE SR

553 KEROSENE SR

762 LIGHT GAS OIL SR

465 HEAVY GAS OIL SR

374 COKER GAS OIL

SECTION 3

92.5 HEAVY COKER GAS OIL

1611 ATMOSPHERIC RESIDUUM

109 CALCINED COKE

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PETROVIETNAM REFINERY

REFINING SCHEME N° 6

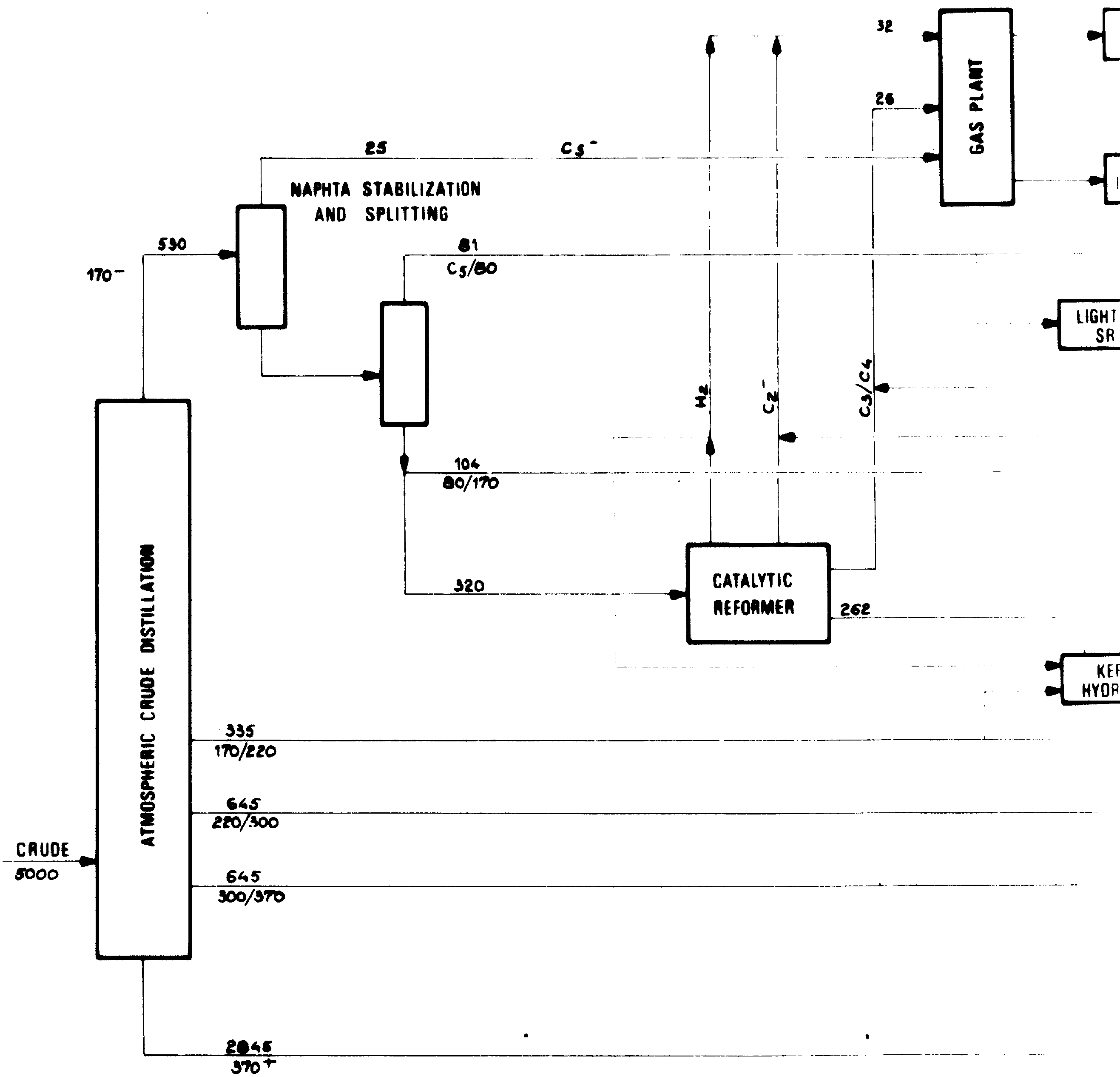
MINAS / ARABIAN LIGHT FEED

50 / 50 %

SCALE

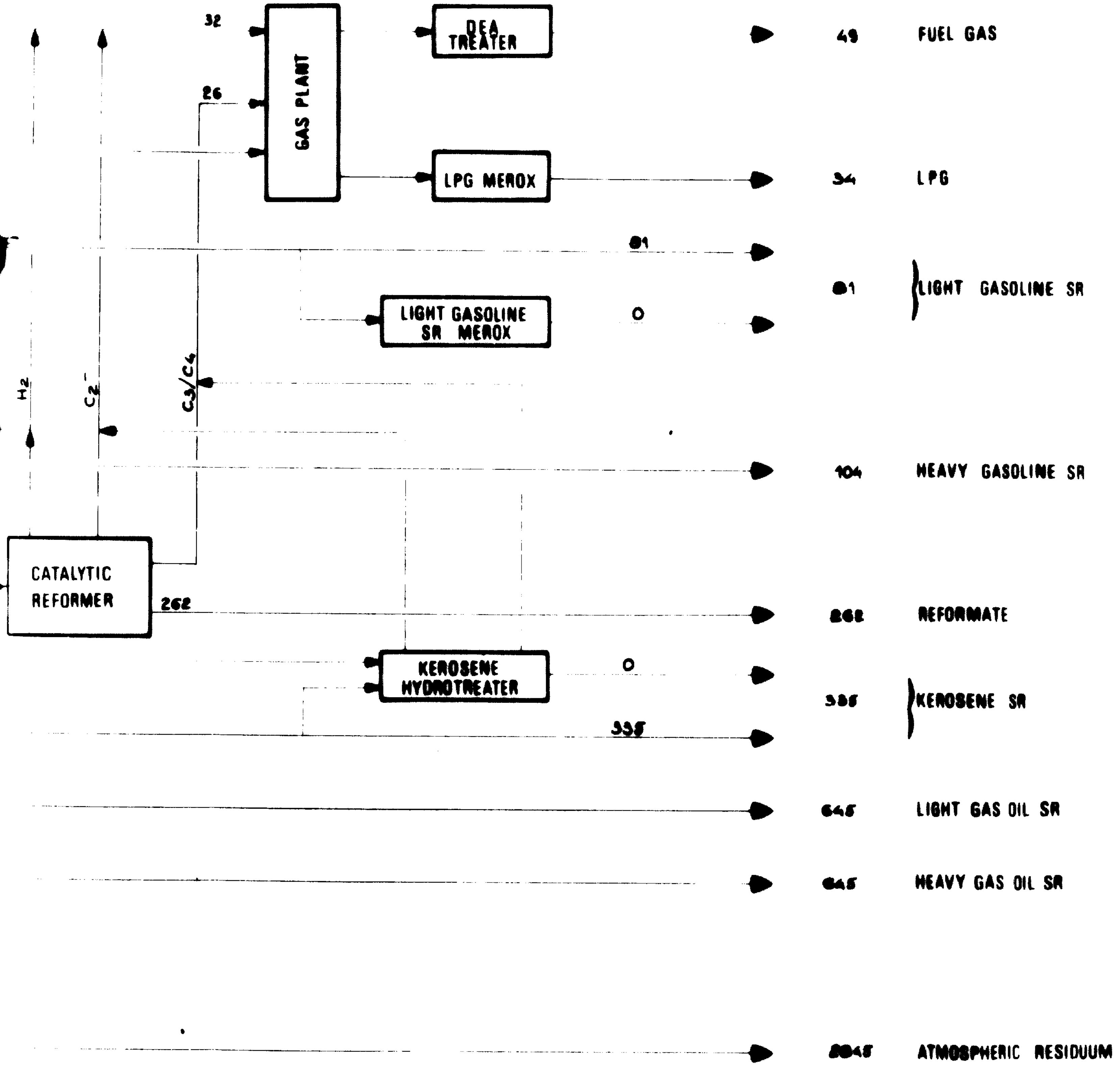
09/78 78060 - A . 106

REV


32
26
GAS PLANT
25
C_5^-
NAPHTA STABILIZATION
AND SPLITTING
530
170⁻
81
C_5/80
LIGHT
SR
H_2
C_2^-
C_3/C_4
104
80/170
320
CATALYTIC
REFORMER
262
KER
HYDR
335
170/220
645
220/300
CRUDE
5000
ATMOSPHERIC CRUDE DISTILLATION
645
300/370
2845
370⁺

SECTION 1

MATERIAL BALANCE 10^3 T/YEAR



49 FUEL GAS

34 LPG

81

81 LIGHT GASOLINE SR

0

104 HEAVY GASOLINE SR

262 REFORMATE

0

335 KEROSENE SR

35

645 LIGHT GAS OIL SR

645 HEAVY GAS OIL SR

2045 ATMOSPHERIC RESIDUUM

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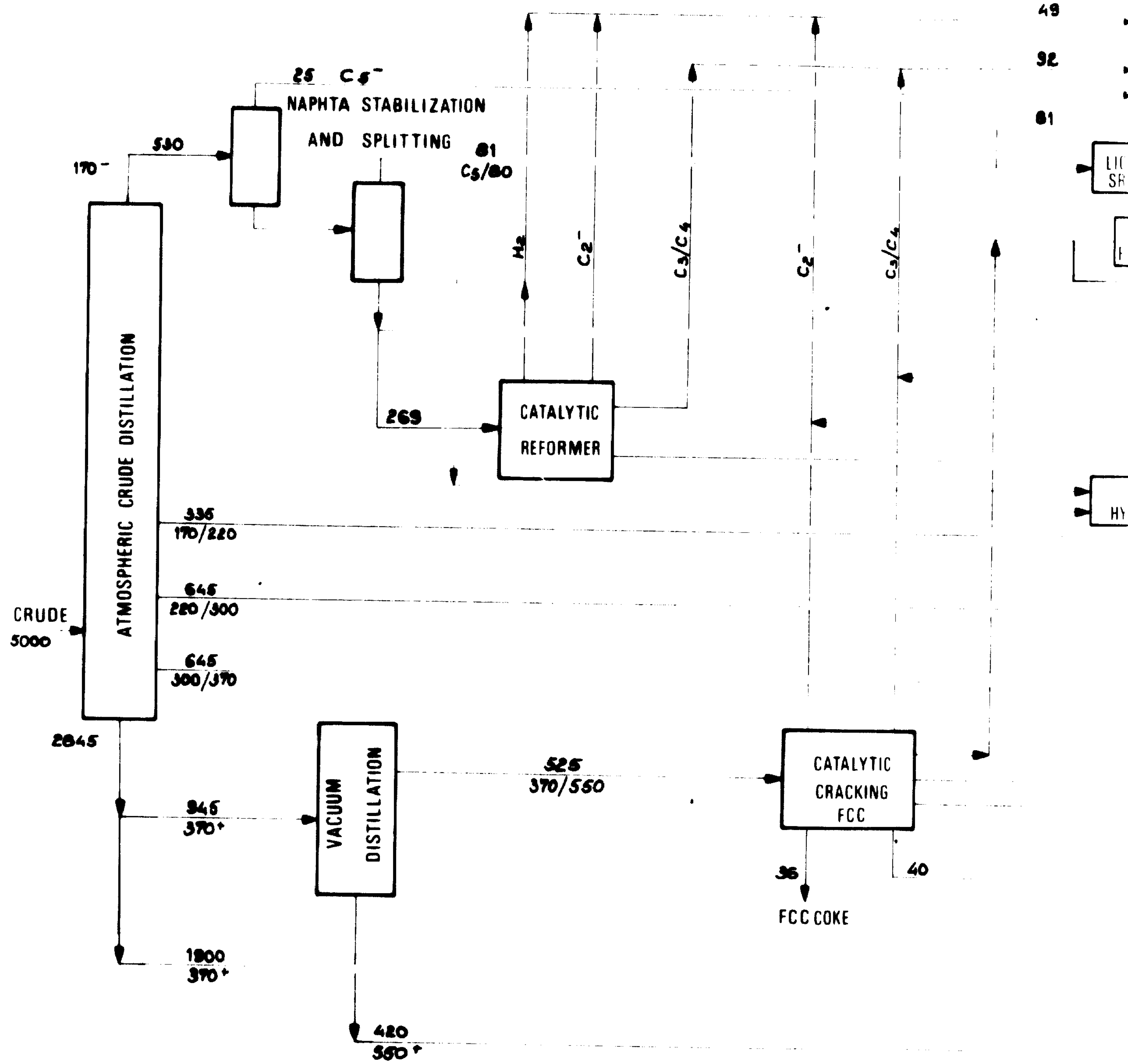
PETROVIETNAM REFINERY
REFINING SCHEME N° 1
MINAS/ARABIAN 50/50 DESIGN BASIS
100% MINAS CRUDE FEED
MATERIAL BALANCE

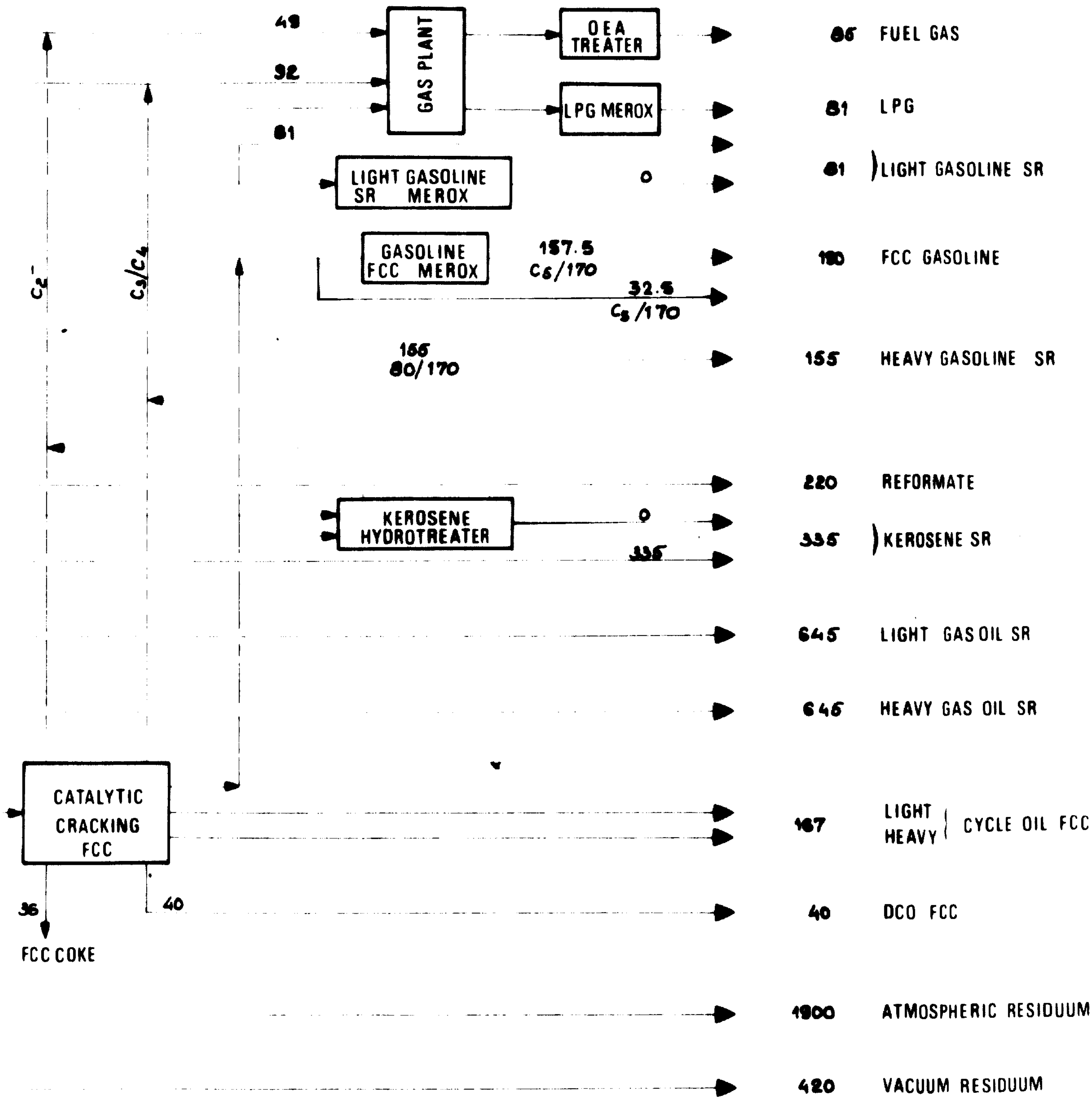
SCALE		REV
	09/78 78 060-A-111	

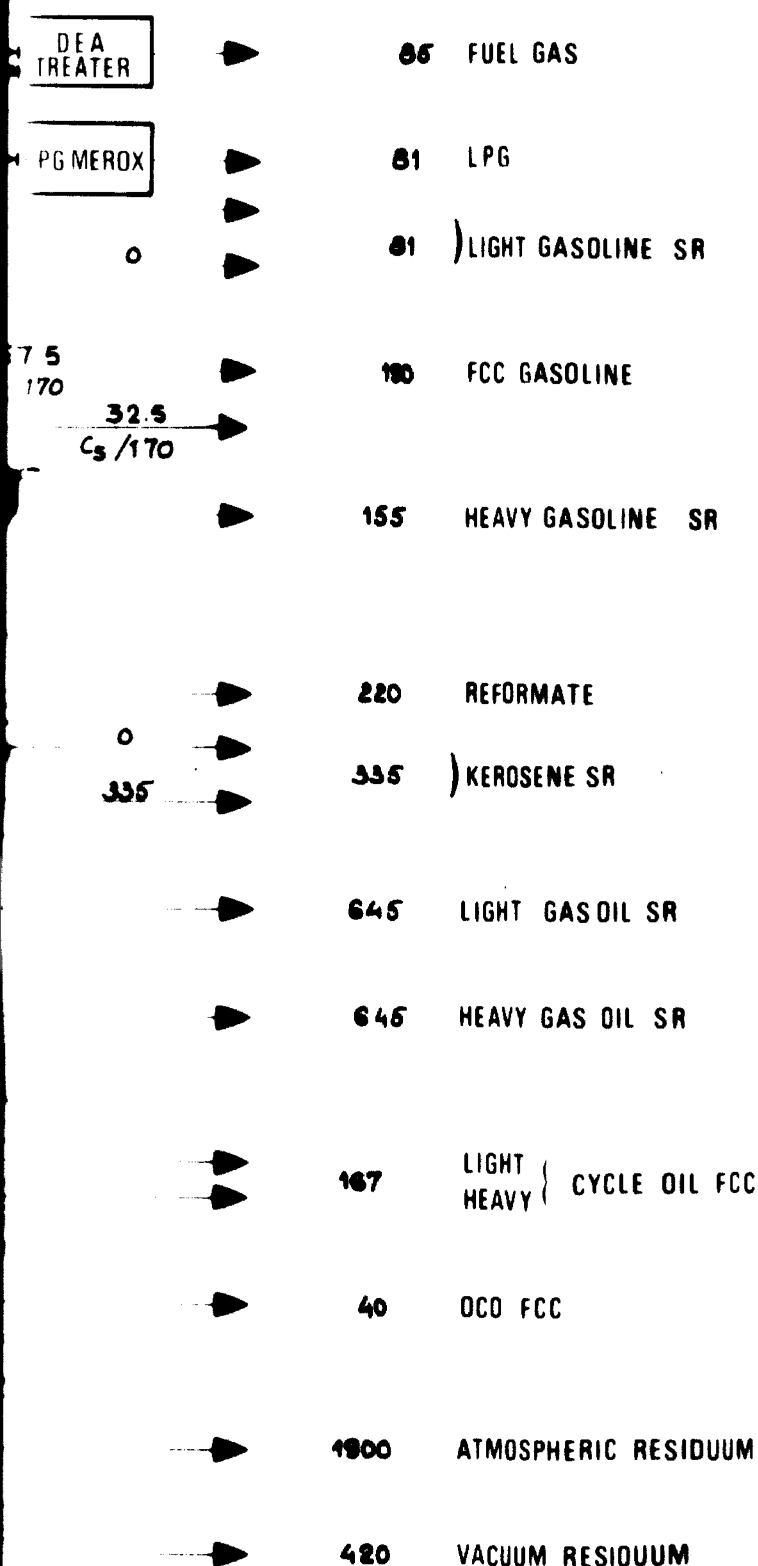


25 C5⁻
NAPHTA STABILIZATION
AND SPLITTING
530
170⁻
81
C5/80
H2
C2⁻
C3/C4
C2⁻
C3/C4
49
32
81
CATALYTIC
REFORMER
269
ATMOSPHERIC CRUDE DISTILLATION
336
170/220
645
220/300
645
300/370
CRUDE
5000
2845
VACUUM
DISTILLATION
525
370/550
CATALYTIC
CRACKING
FCC
945
370⁺
1900
370⁺
36
40
FCC COKE
420
550⁺

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR





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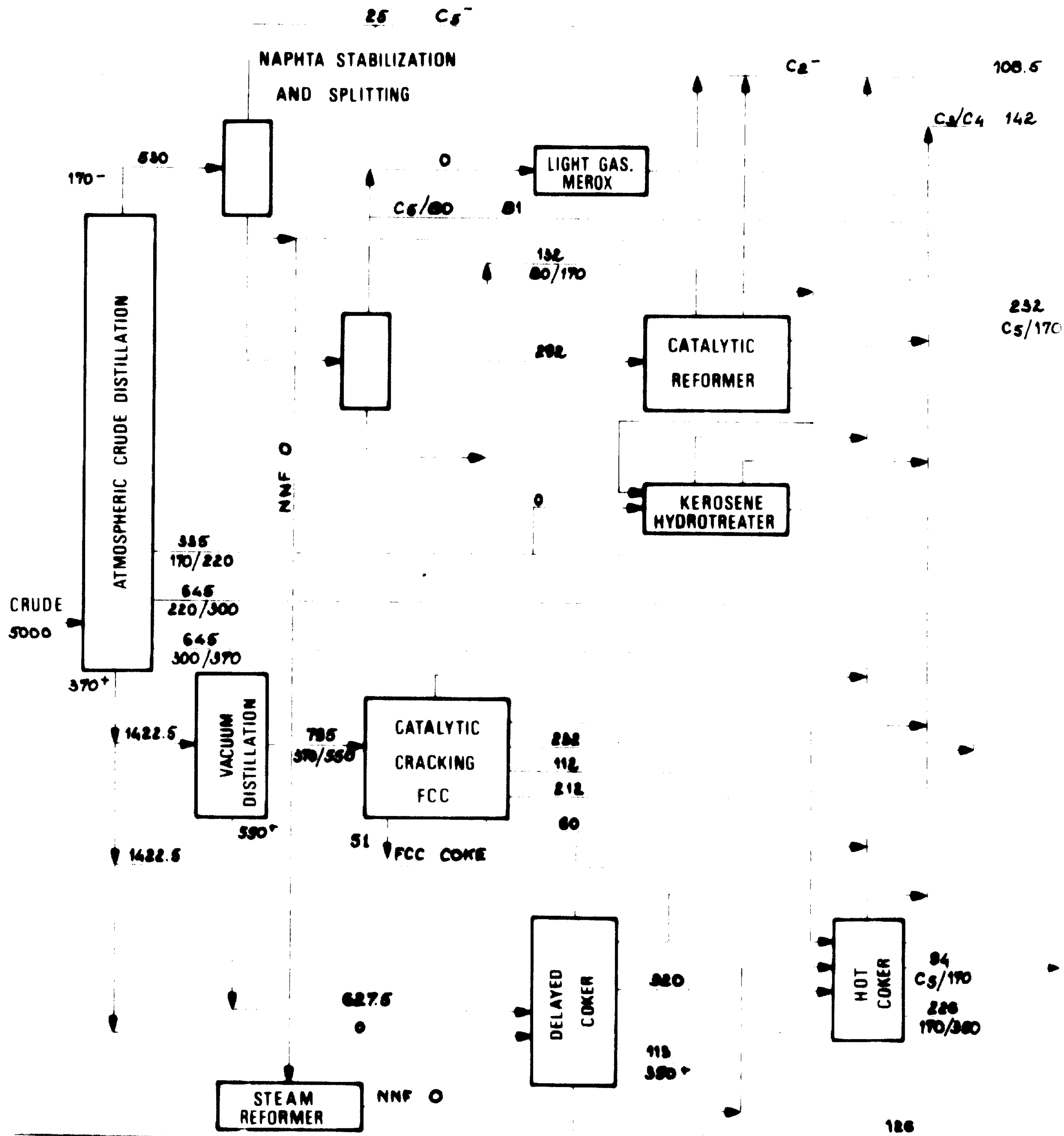
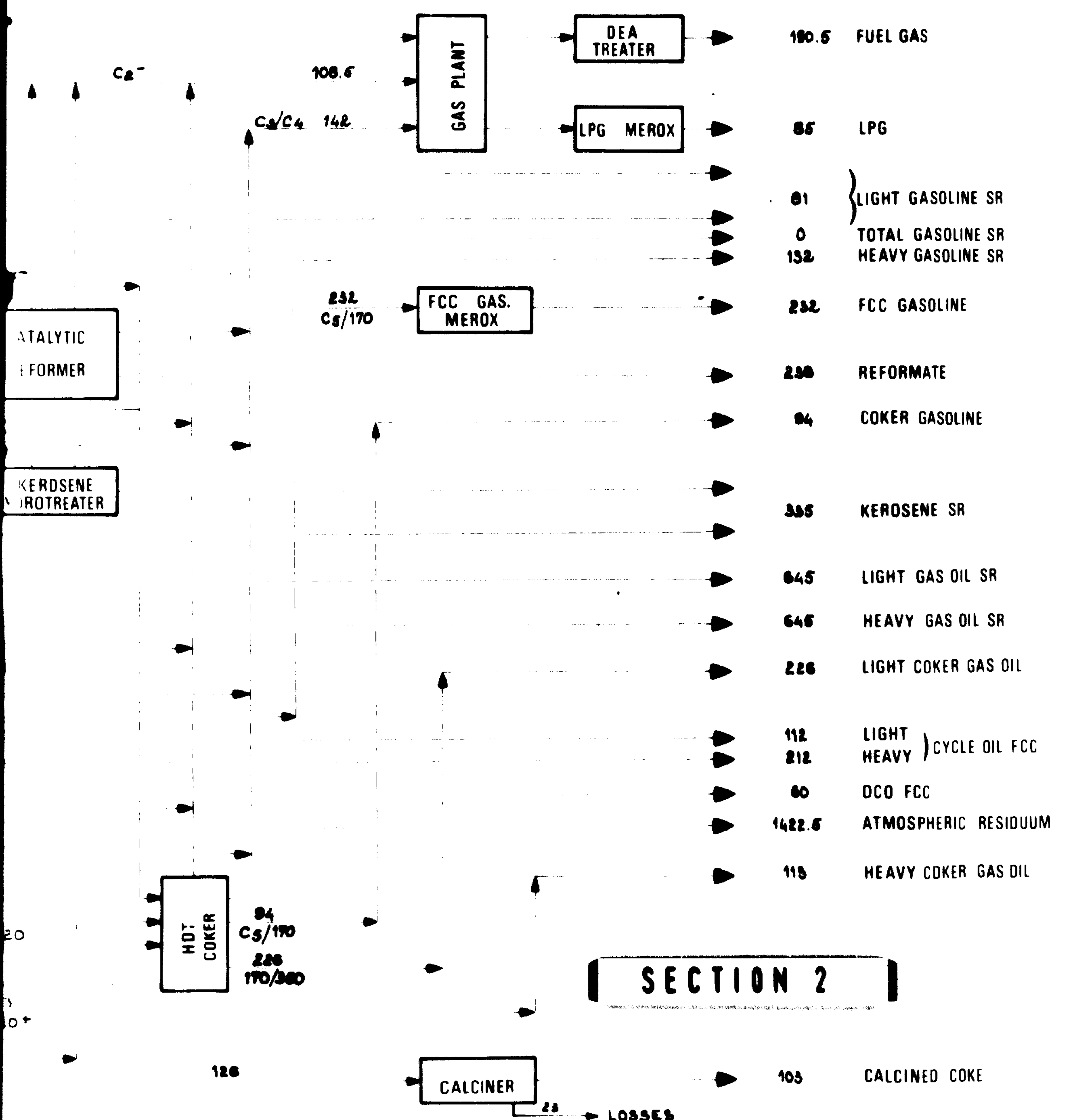
PETROVIETNAM REFINERY
REFINING SCHEME N°2
MINAS/ARABIAN 50/50 DESIGN BASIS
100% MINAS CRUDE FEED
MATERIAL BALANCE

SCALE	09/78	78060 . A . 112


NAPHTA STABILIZATION
AND SPLITTING
LIGHT GAS.
MEROX
ATMOSPHERIC CRUDE DISTILLATION
CATALYTIC
REFORMER
KEROSENE
HYDROTREATER
CRUDE
5000
170/220
220/300
300/370
370+
1422.5
VACUUM
DISTILLATION
CATALYTIC
CRACKING
FCC
FCC COKE
DELAYED
COKER
HOT
COKER
STEAM
REFORMER
NNF O
108.5
142
232
C5/170
80/170
C5/170
170/350
627.5
126

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



DEA TREATER

LPG MEROX

190.5	FUEL GAS
85	LPG
81	LIGHT GASOLINE SR
0	TOTAL GASOLINE SR
132	HEAVY GASOLINE SR
232	FCC GASOLINE
238	REFORMATE
94	COKER GASOLINE
335	KEROSENE SR
645	LIGHT GAS OIL SR
645	HEAVY GAS OIL SR
226	LIGHT COKER GAS OIL
112	LIGHT CYCLE OIL FCC
212	HEAVY CYCLE OIL FCC
60	OCO FCC
1422.5	ATMOSPHERIC RESIDUUM
115	HEAVY COKER GAS OIL
105	CALCINED COKE

← LOSSES

SECTION 3

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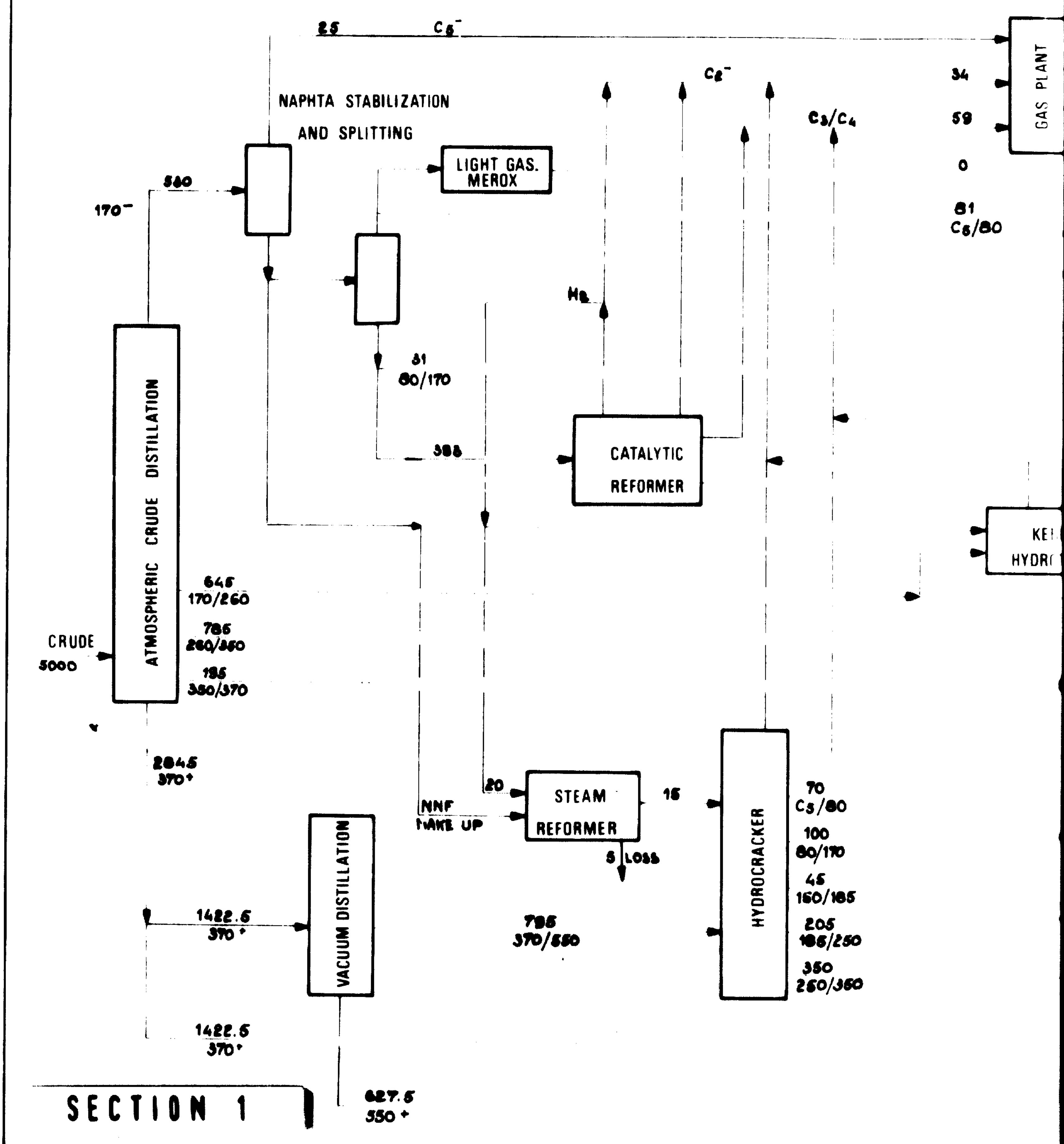
DIVISION DES ÉTUDES INDUSTRIELLES

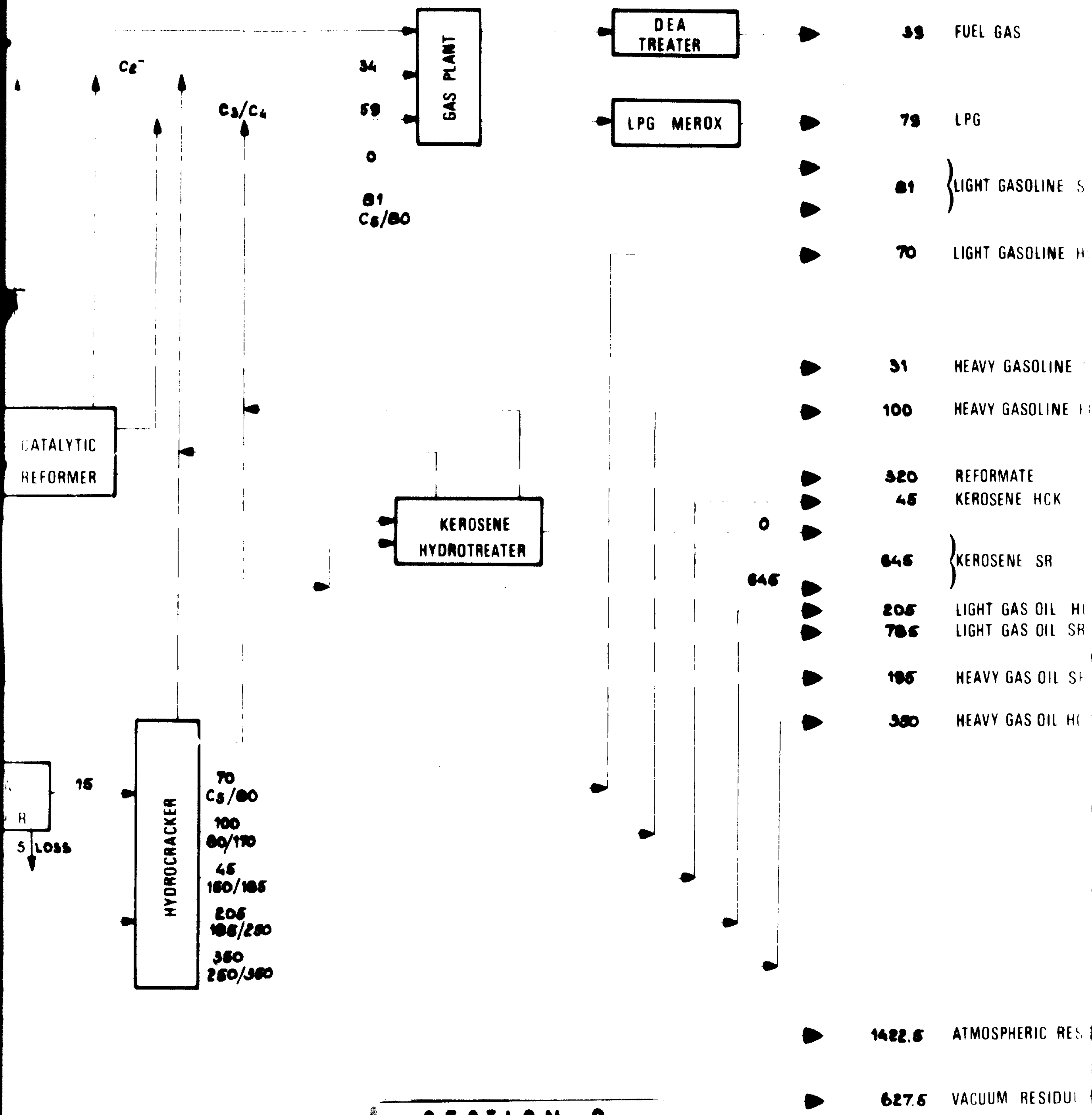
PETROVIETNAM REFINERY
REFINING SCHEME N° 3
MINAS/ARABIAN 50/50 DESIGN BASIS
100% MINAS CRUDE FEED
MATERIAL BALANCE

SCALE | 09/78 | 78060 . A . 113 | REV.


25
C_5^-
GAS PLANT
34
59
0
81
$C_5/80$
C_2^-
C_3/C_4
NAPHTA STABILIZATION
AND SPLITTING
LIGHT GAS. MEROX
580
170⁻
H_2
31
80/170
388
CATALYTIC
REFORMER
ATMOSPHERIC CRUDE DISTILLATION
CRUDE
5000
645
170/260
785
260/350
135
350/370
2845
370⁺
20
NNF
MAKE UP
STEAM
REFORMER
15
5 LOSS
HYDROCRACKER
70
$C_5/80$
100
80/170
45
160/185
205
185/250
350
250/350
795
370/550
1422.5
370⁺
VACUUM DISTILLATION
1422.5
370⁺
827.5
550⁺
KE
HYDR

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

DEA TREATER

LPG MEROX

39	FUEL GAS
79	LPG
81	LIGHT GASOLINE SR
70	LIGHT GASOLINE HCK
31	HEAVY GASOLINE SR
100	HEAVY GASOLINE HCK
320	REFORMATE
45	KEROSENE HCK
645	KEROSENE SR
205	LIGHT GAS OIL HCK
785	LIGHT GAS OIL SR
195	HEAVY GAS OIL SR
350	HEAVY GAS OIL HCK
1422.5	ATMOSPHERIC RESIDUUM
627.5	VACUUM RESIDUUM

0

646

SECTION 3

beicip

DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY

REFINING SCHEME N° 4

MINAS/ARABIAN 50/50 DESIGN BASIS

100% MINAS CRUDE FEED

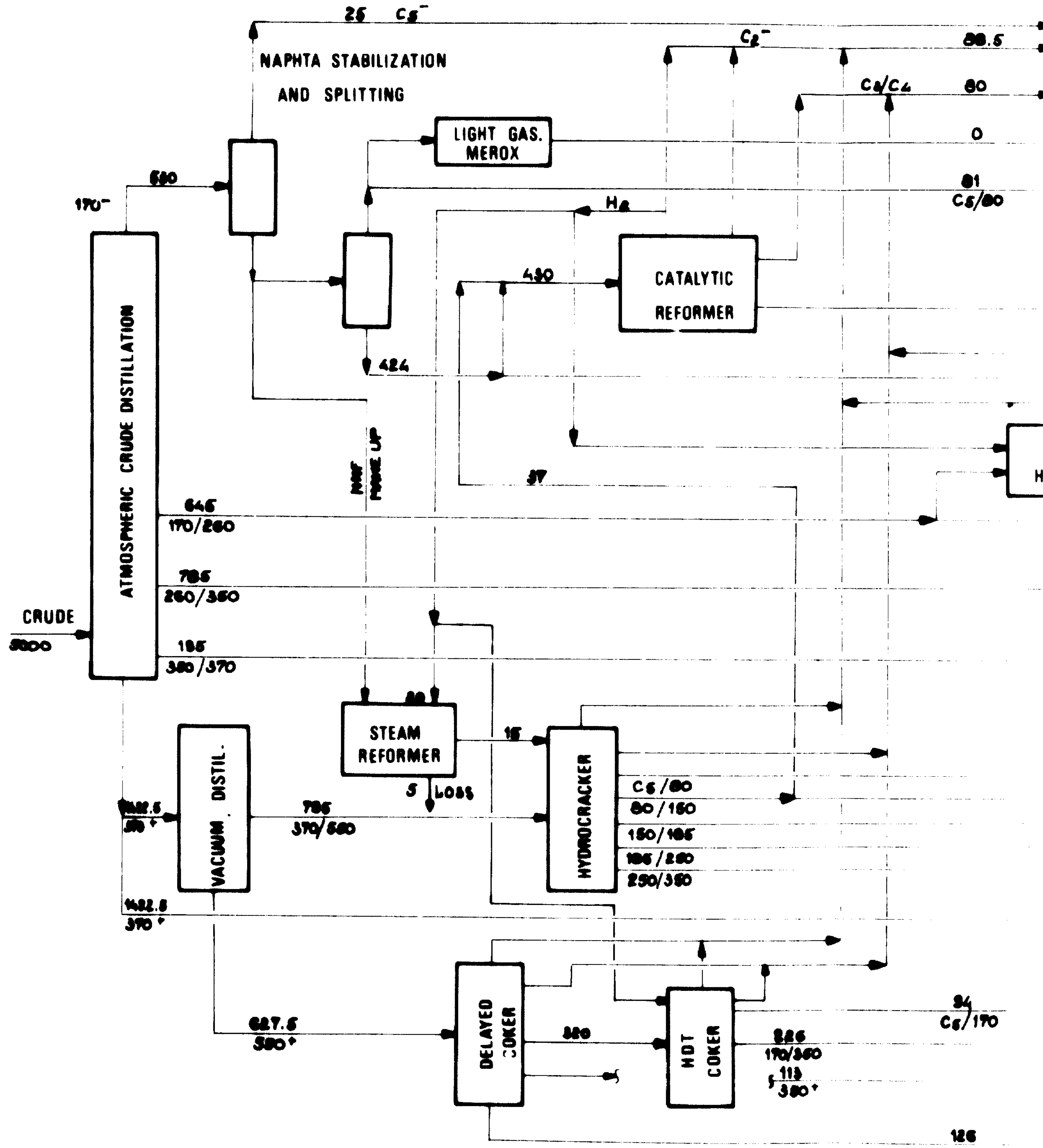
MATERIAL BALANCE

SCALE

09/78 78060-A-114

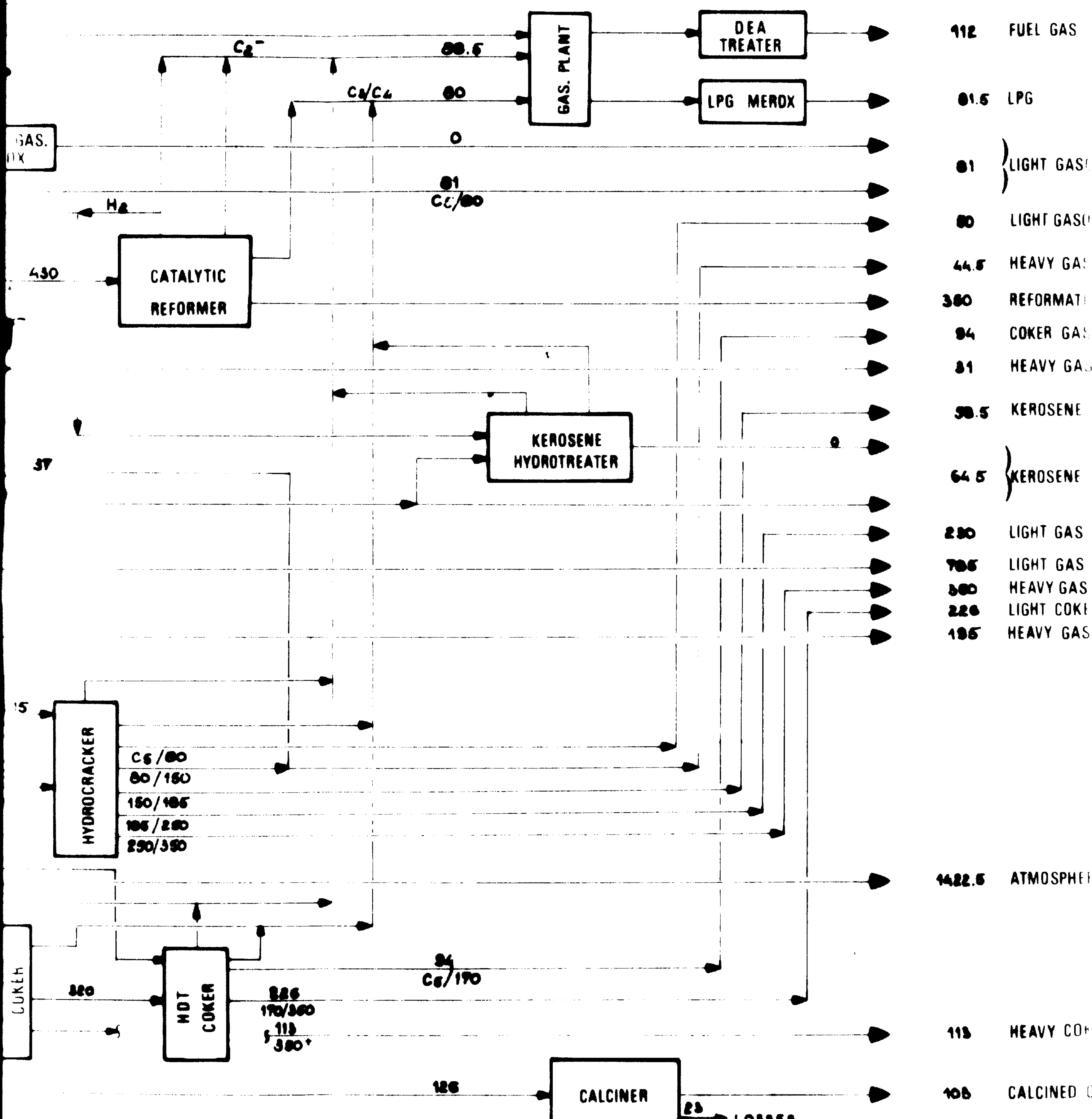
REV.

MATERIAL BALANCE



SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



DEA TREATER → 112 FUEL GAS

LPG MEROX → 81.5 LPG

81	LIGHT GASOLINE SR
80	LIGHT GASOLINE HCK
44.5	HEAVY GASOLINE HCK
360	REFORMATE
94	COKER GASOLINE
81	HEAVY GASOLINE SR
58.5	KEROSENE HCK
0	
64.5	KEROSENE SR
230	LIGHT GAS OIL HCK
785	LIGHT GAS OIL SR
360	HEAVY GAS OIL HCK
226	LIGHT COKER GAS OIL
195	HEAVY GAS OIL SR
1422.5	ATMOSPHERIC RESIDUUM
115	HEAVY COKER GAS OIL
105	CALCINED COKE

→ LOSSES

SECTION 3

beicip

DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY

REFINING SCHEME N° 5

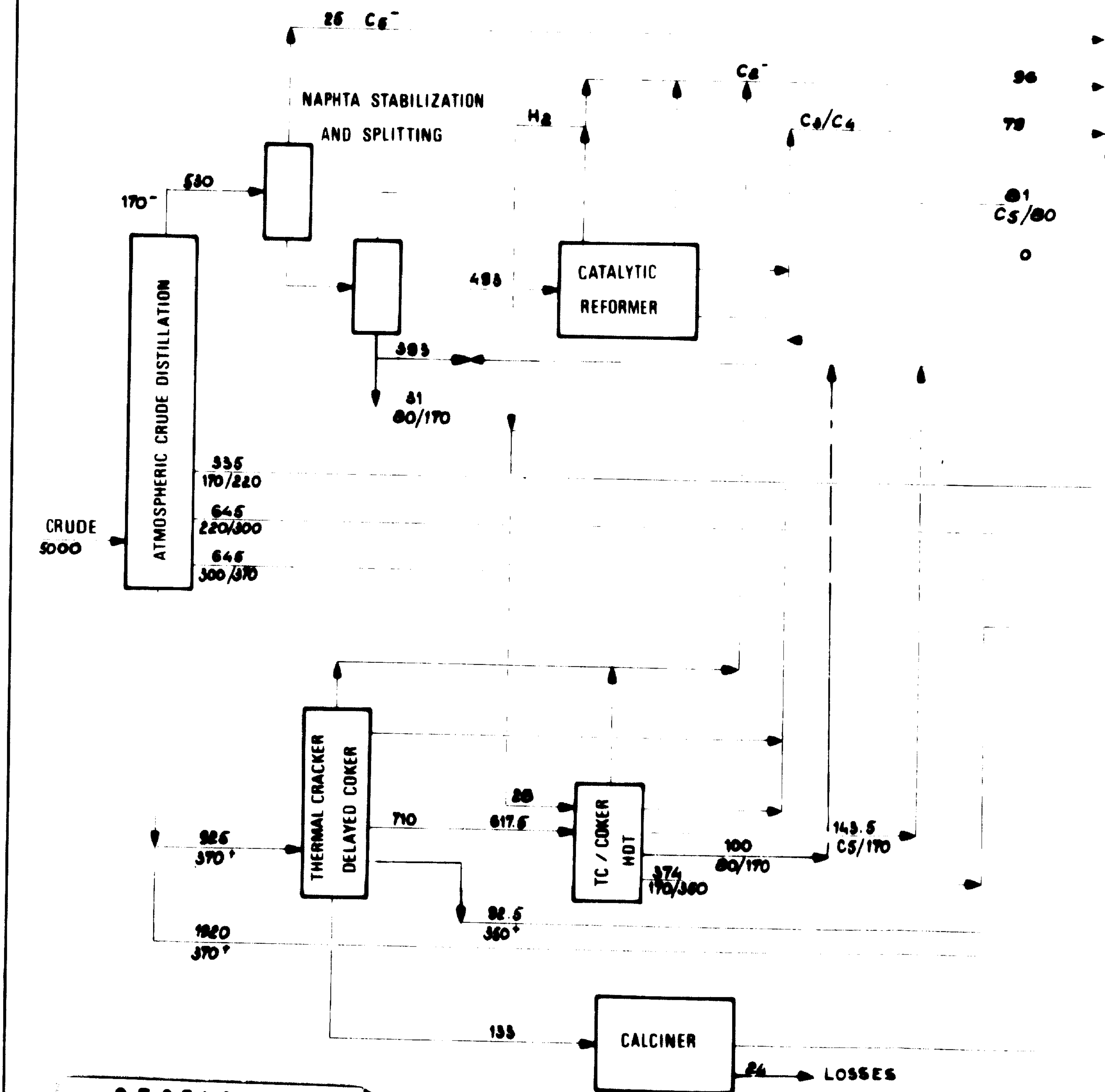
MINAS/ARABIAN 50/50 DESIGN BASIS

100% MINAS CRUDE FEED

MATERIAL BALANCE

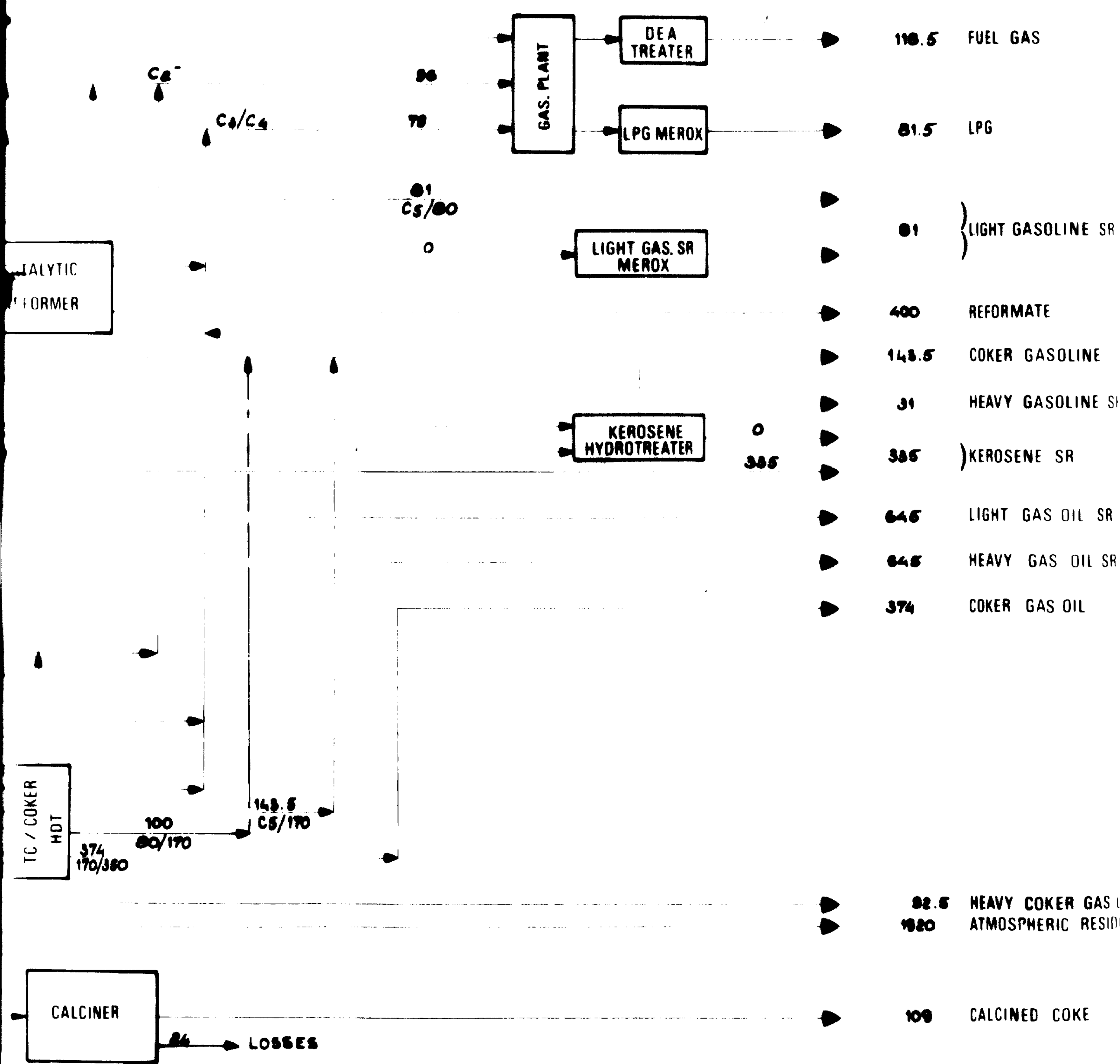
SCALE		REV
	09/78 78 060 - A - 115	

MATERIAL BALANCE 10^3

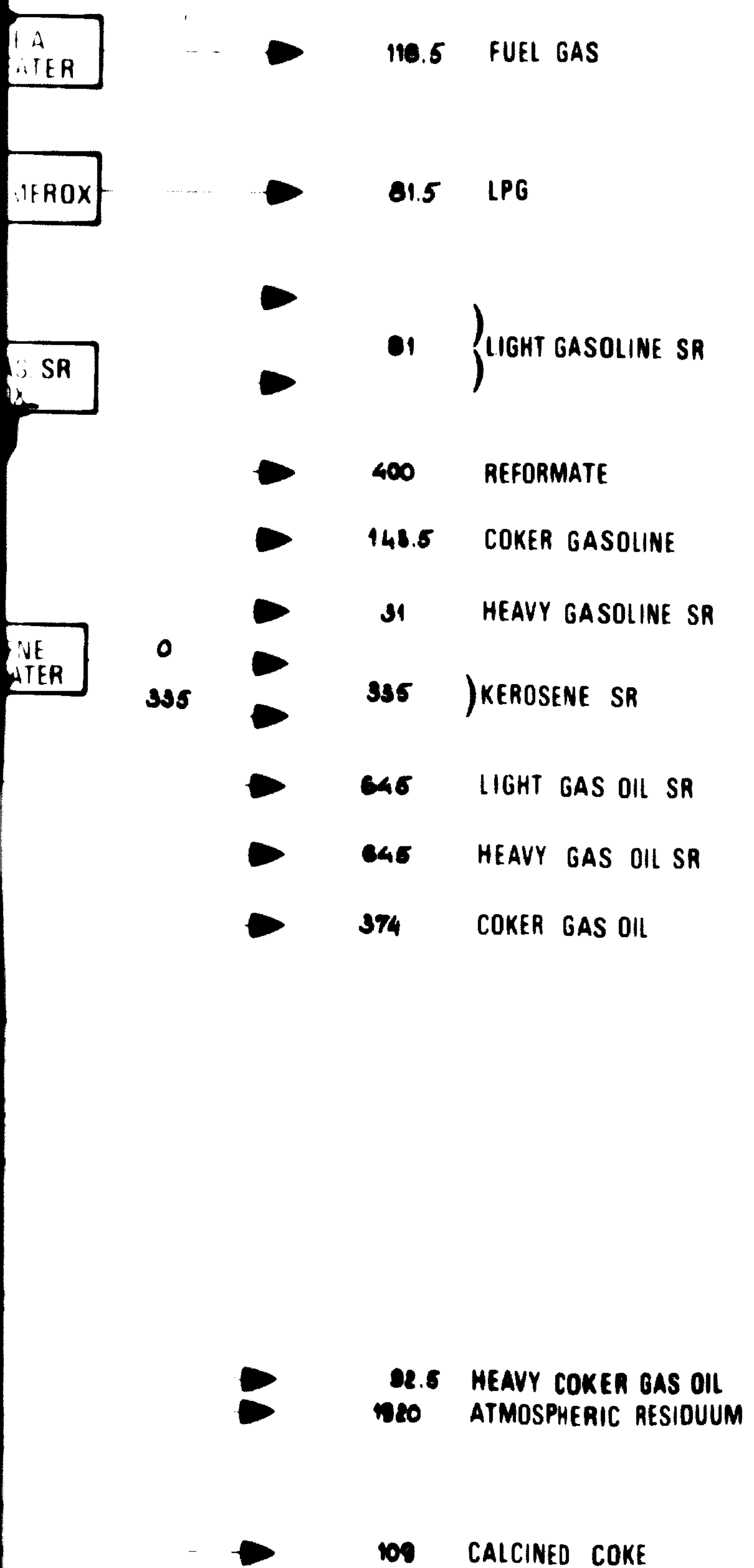


SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

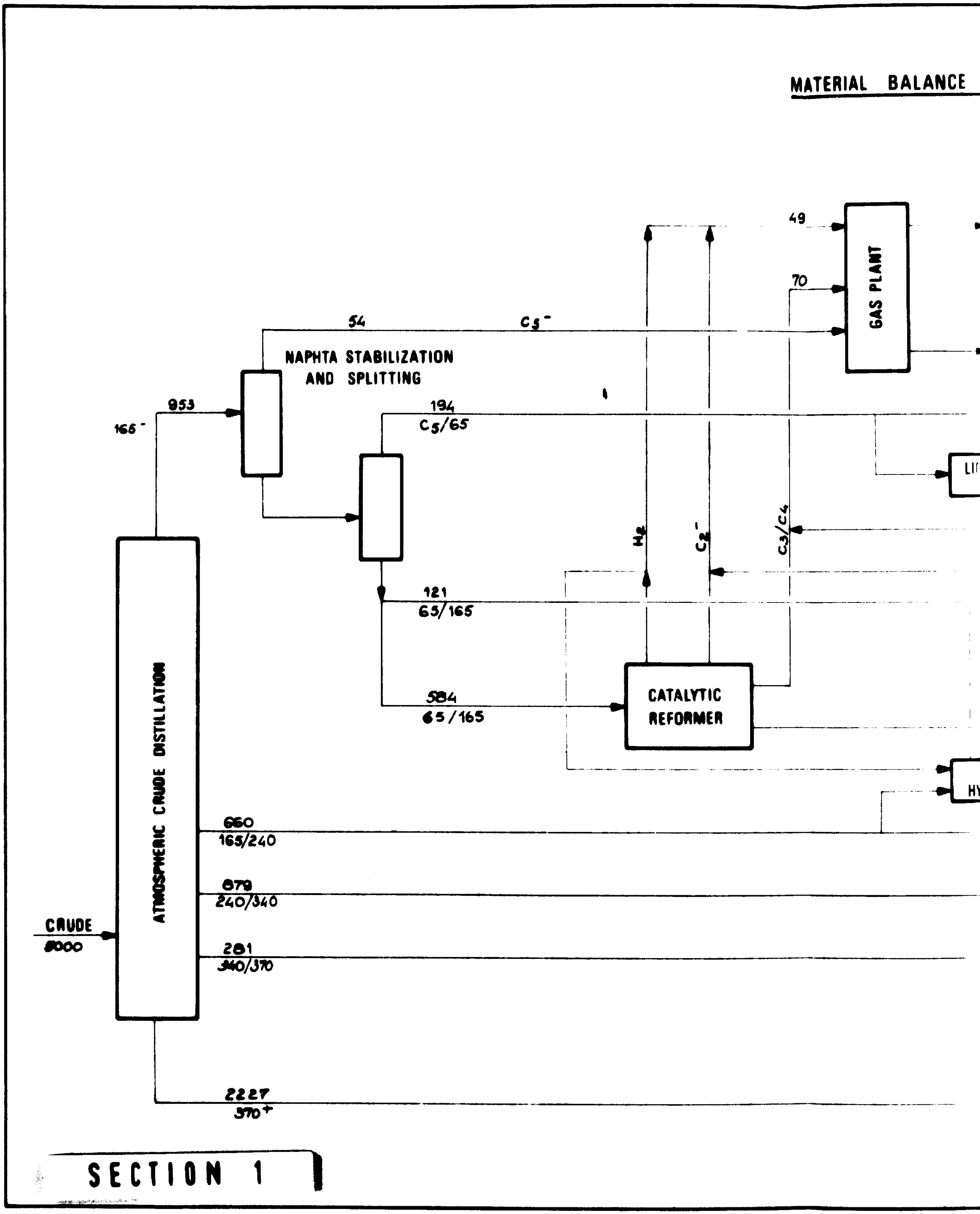


SECTION 3

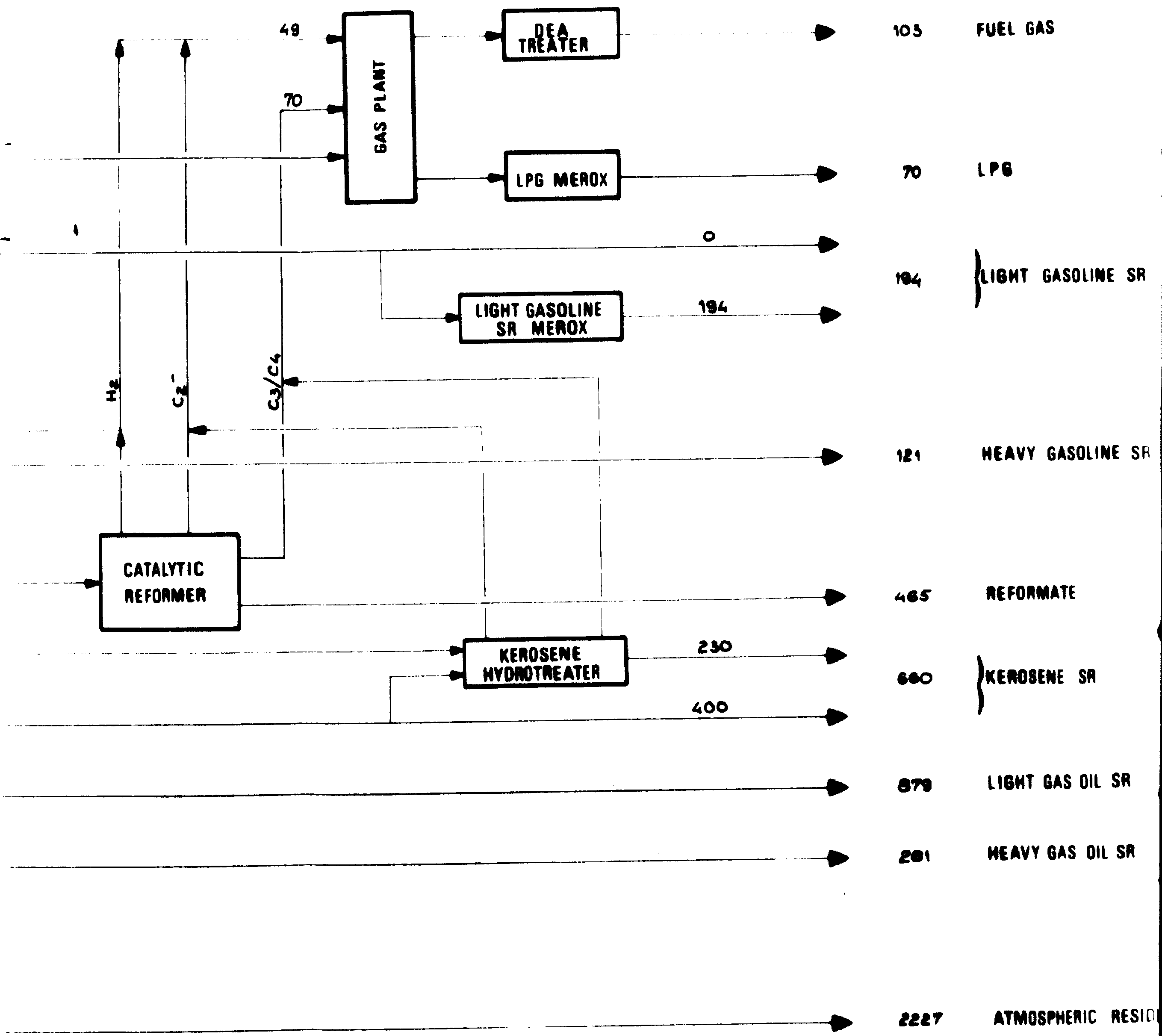
beicip
DIVISION DES ETUDES INDUSTRIELLES

PETROVIETNAM REFINERY
REFINING SCHEME N° 6
MINAS/ARABIAN 50/50 DESIGN BASIS
100% MINAS CRUDE FEED
MATERIAL BALANCE

SCALE		REF.
	09/78 78060 - A - 116	


MATERIAL BALANCE
GAS PLANT
49
70
54
C5-
NAPHTA STABILIZATION AND SPLITTING
953
165-
194
C5/65
H2
C2-
C3/C4
121
65/165
CATALYTIC REFORMER
584
65/165
ATMOSPHERIC CRUDE DISTILLATION
CRUDE
8000
660
165/240
879
240/340
281
340/370
2227
370+
SECTION 1

MATERIAL BALANCE 10^3 T/YEAR



SECTION 2

103	FUEL GAS
70	LPG
194	LIGHT GASOLINE SR
121	HEAVY GASOLINE SR
465	REFORMATE
660	KEROSENE SR
879	LIGHT GAS OIL SR
201	HEAVY GAS OIL SR
2227	ATMOSPHERIC RESIDUUM

194

30

SECTION 3

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DIVISION DES ÉTUDES INDUSTRIELLES

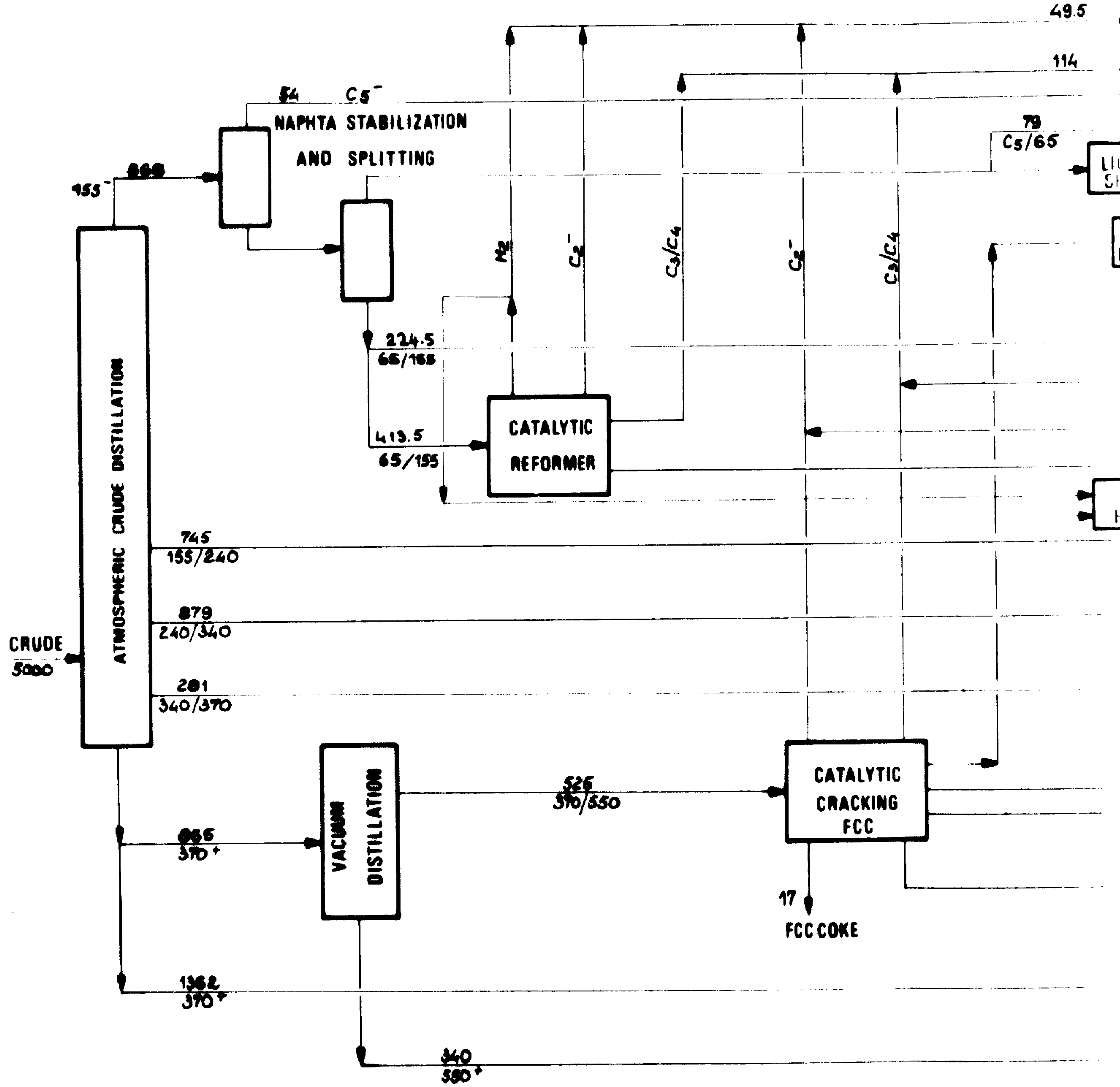
PETROVIETNAM REFINERY
REFINING SCHEME N° 1
MINAS/ARABIAN 50/50 DESIGN BASIS
100% ARABIAN CRUDE FEED
MATERIAL BALANCE

SCALE

09/7[illegible] 7[illegible]060 - A - 121

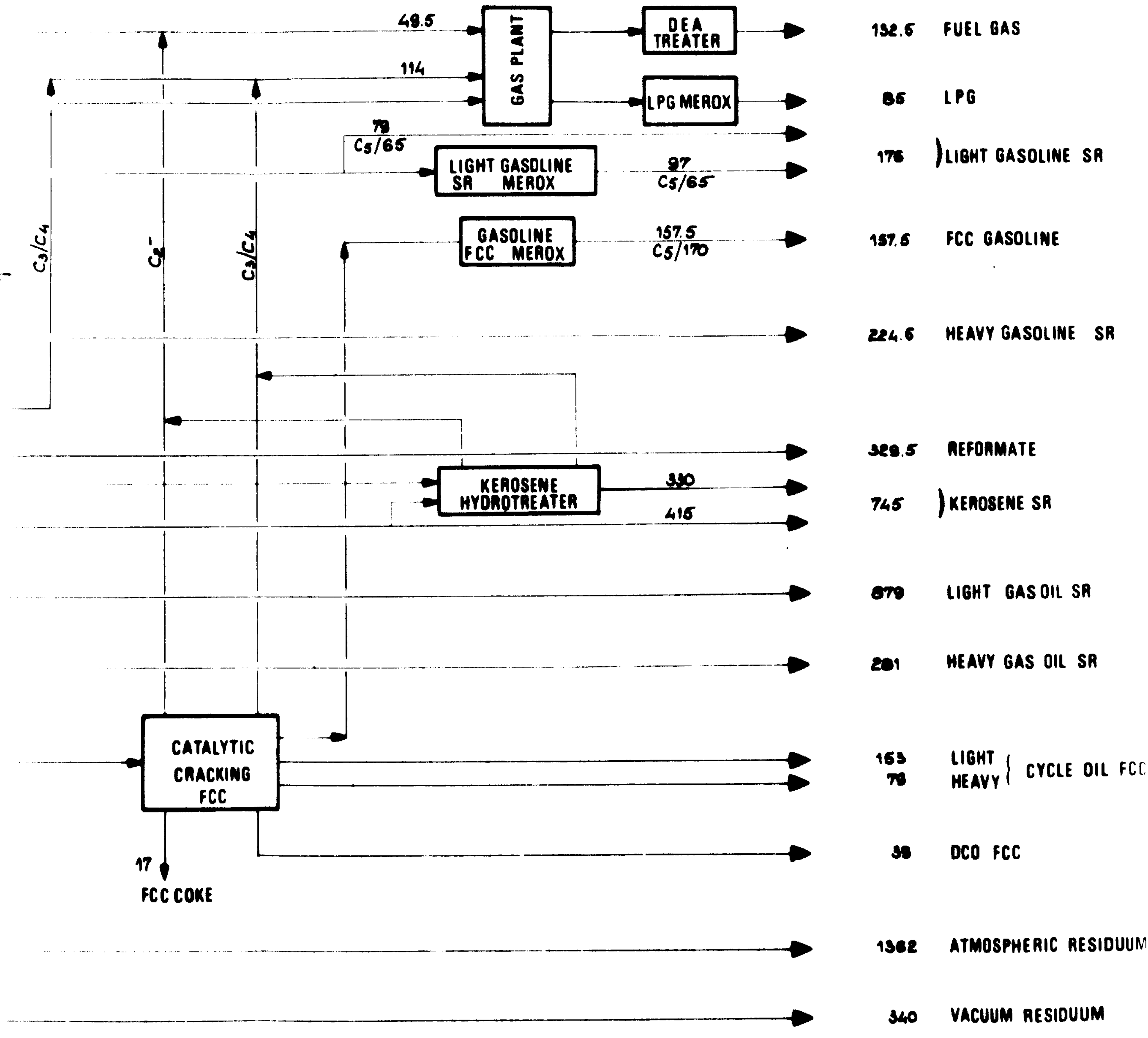
REV

MATERIAL BALANCE 10



SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

DEA TREATER →	132.5	FUEL GAS
LPG MEROX →	85	LPG
→ 97 C5/65 →	176	LIGHT GASOLINE SR
157.5 C5/170 →	157.6	FCC GASOLINE
→	224.6	HEAVY GASOLINE SR
→	329.5	REFORMATE
330 → 415 →	745	KEROSENE SR
→	879	LIGHT GASOIL SR
→	281	HEAVY GAS OIL SR
→	153	LIGHT CYCLE OIL FCC
→	78	HEAVY CYCLE OIL FCC
→	39	OCO FCC
→	1362	ATMOSPHERIC RESIDUUM
→	340	VACUUM RESIDUUM

SECTION 3

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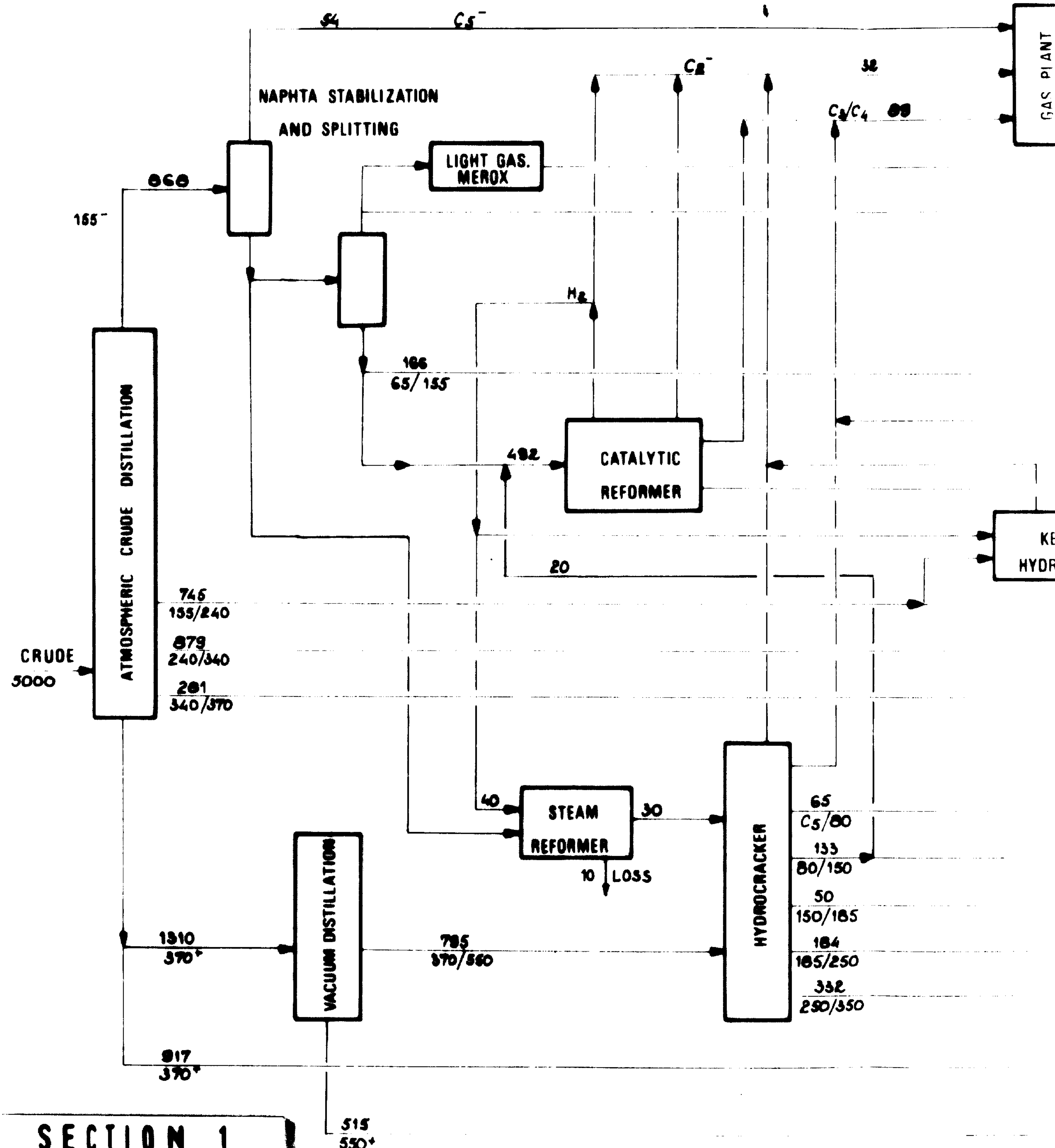
DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY
REFINING SCHEME N° 2
MINAS/ARABIAN 50/50 DESIGN BASIS
100% ARABIAN CRUDE FEED
MATERIAL BALANCE

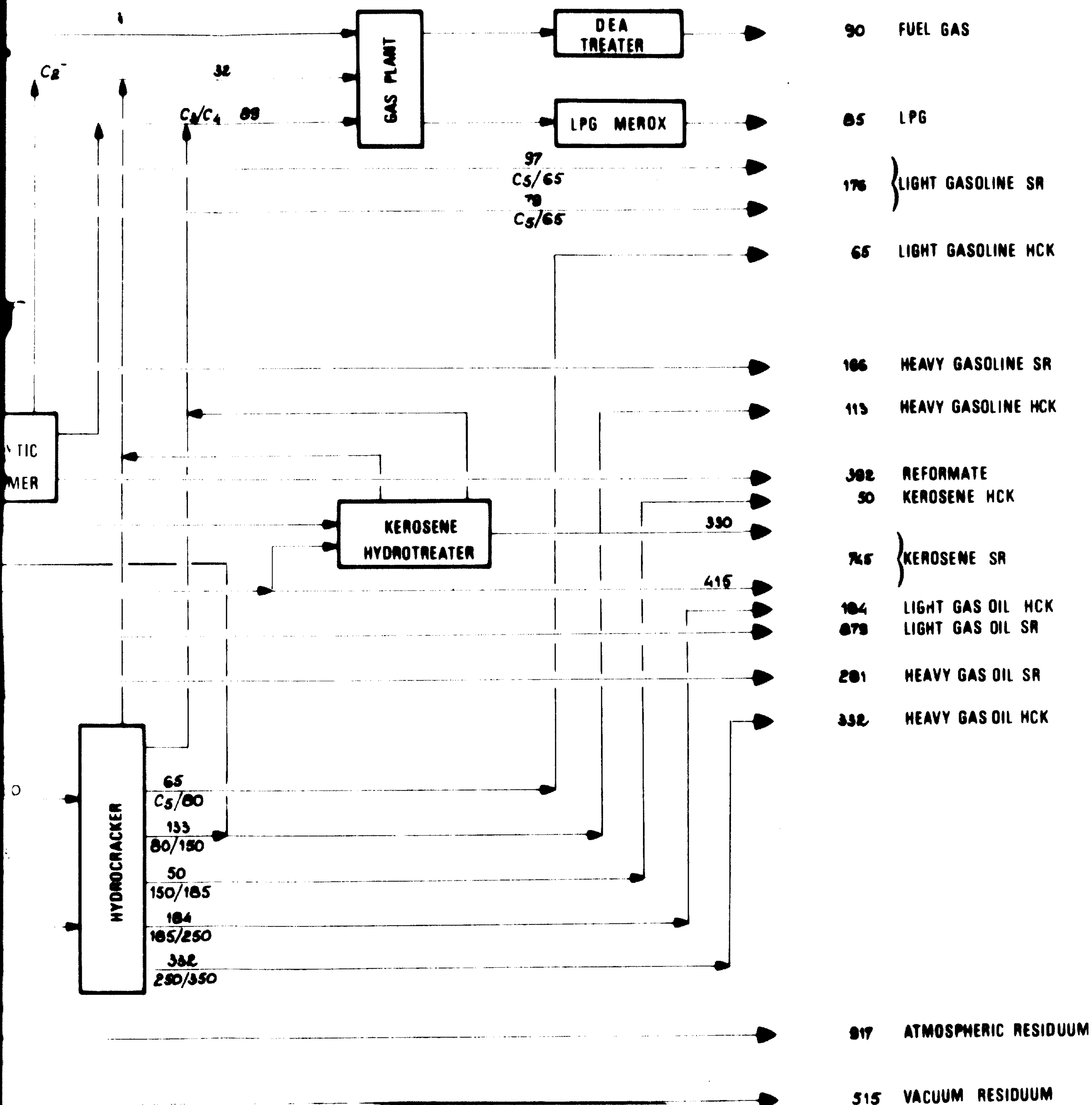
SCALE		REV
	09/78 78060 -A- 122	

MATERIAL BALANCE 1

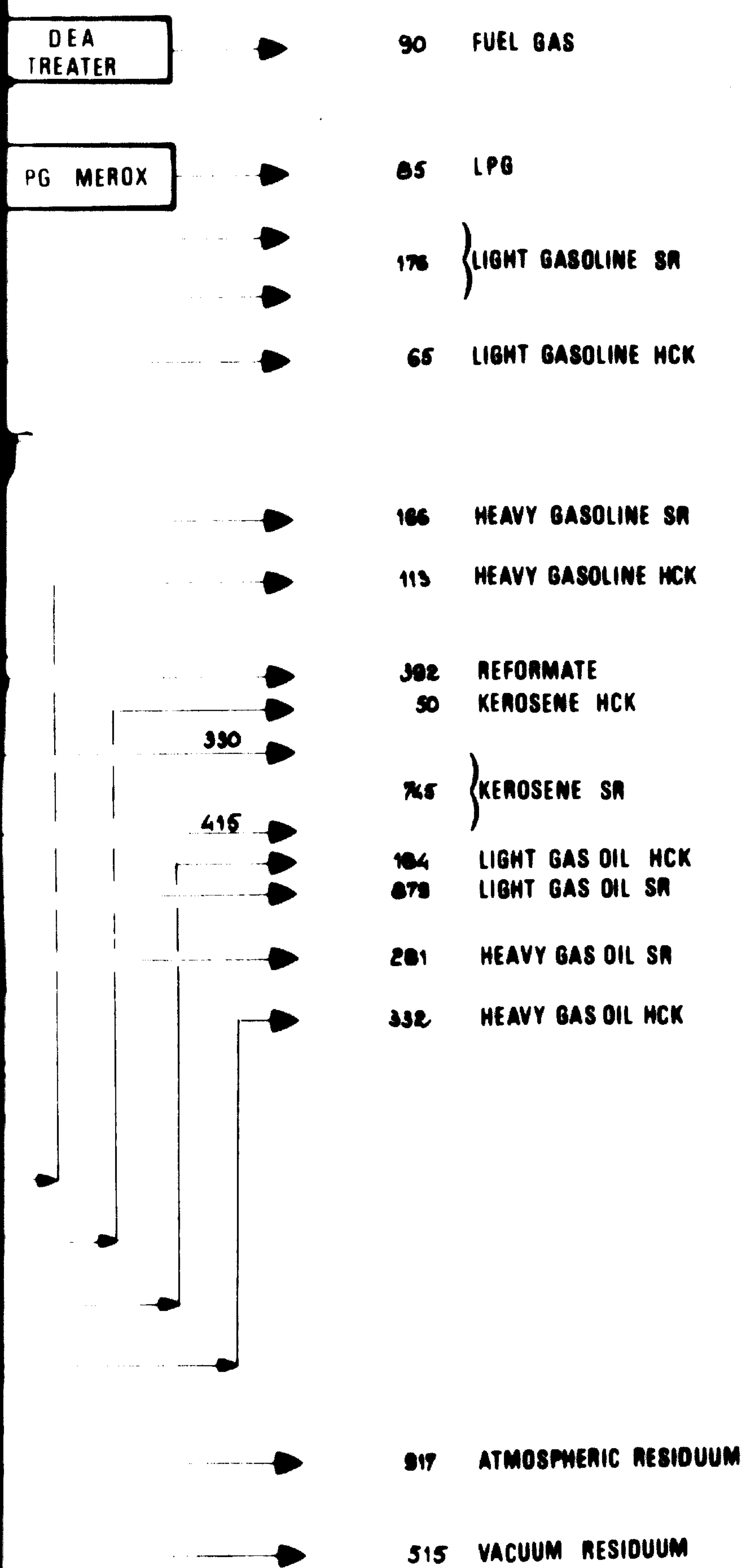


SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2



SECTION 3

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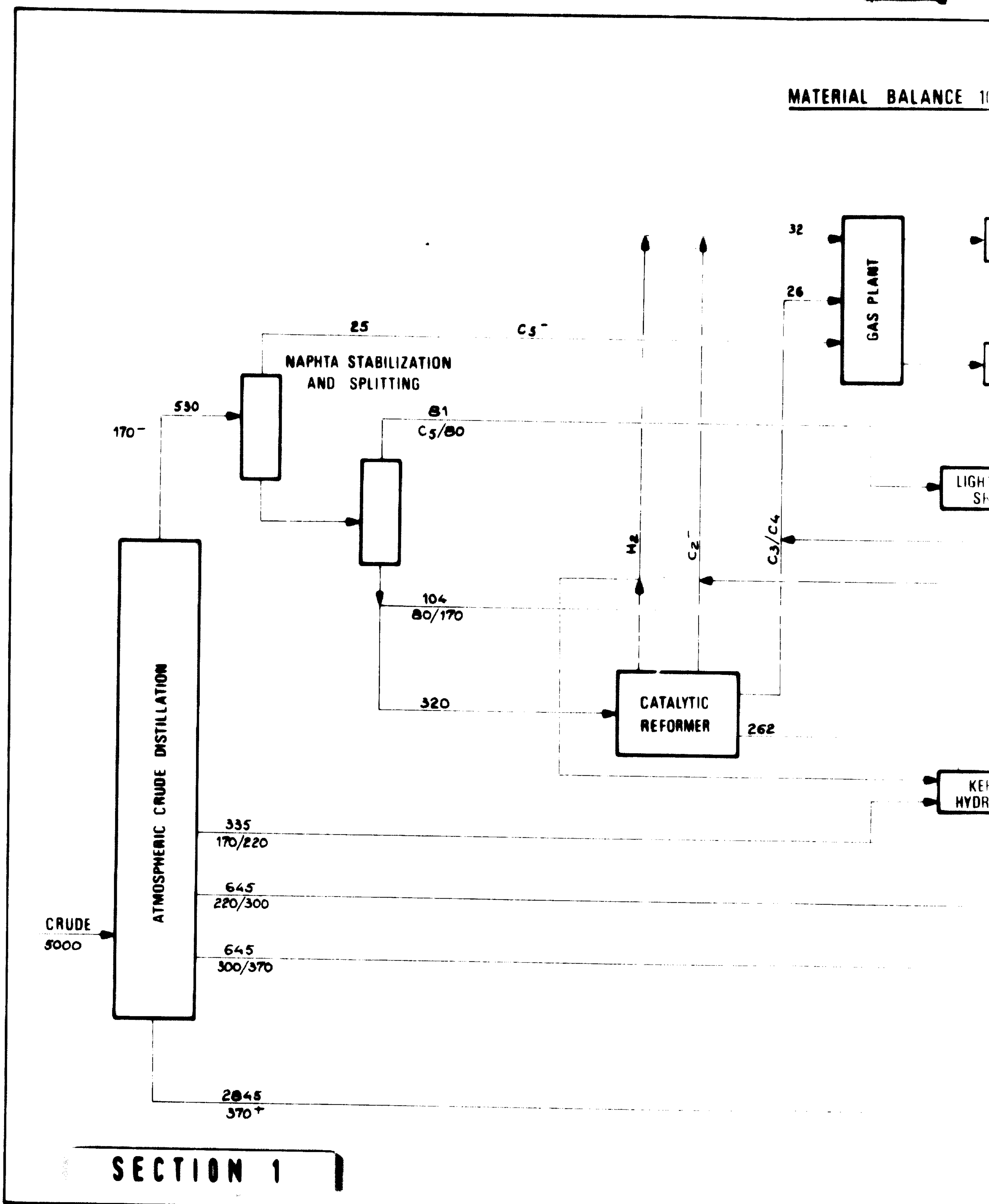
DIVISION DES ETUDES INDUSTRIELLES

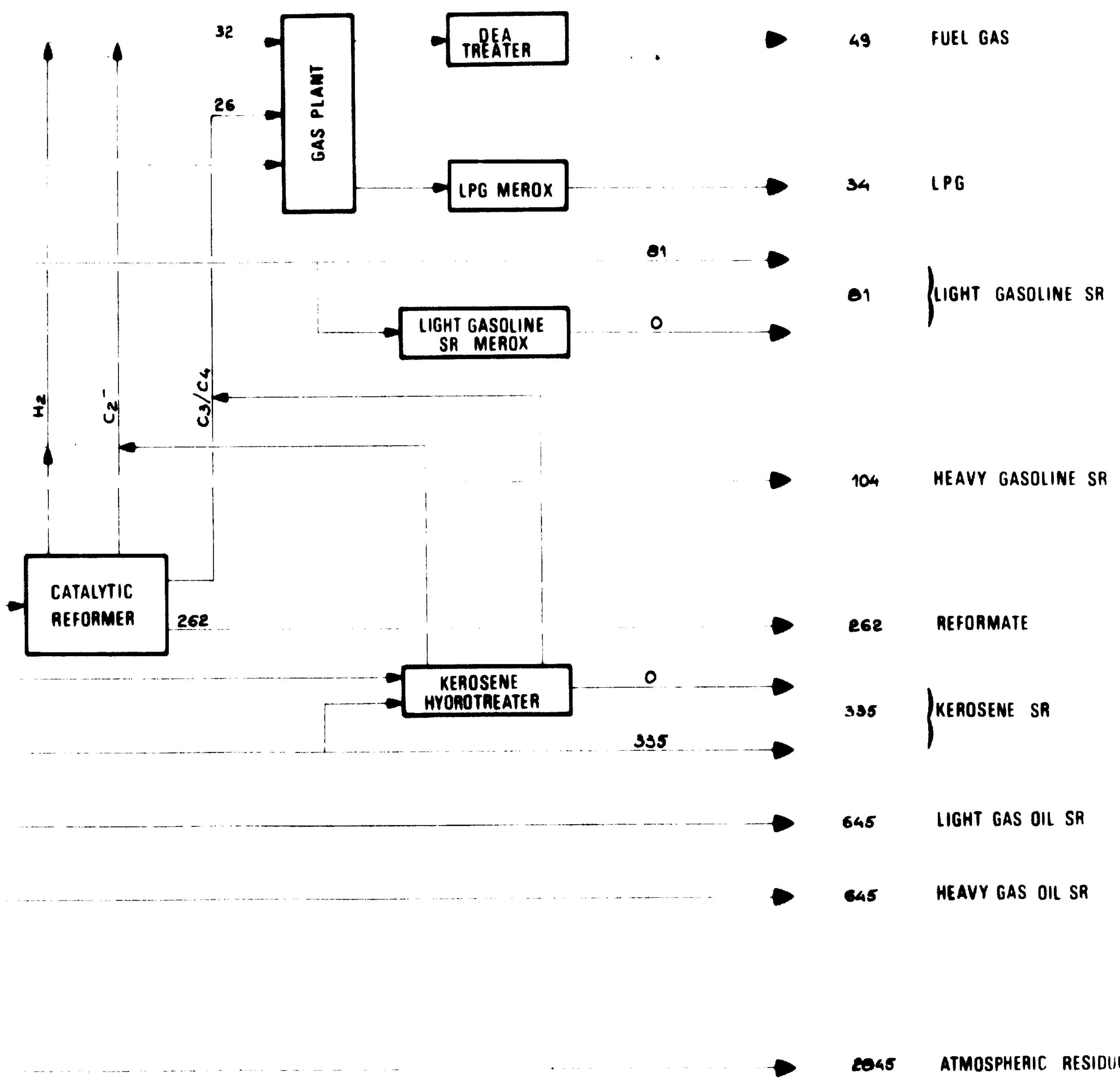
PETROVIETNAM REFINERY
REFINING SCHEME N° 4
MINAS/ARABIAN 50/50 DESIGN BASIS
100% ARABIAN CRUDE FEED
MATERIAL BALANCE

SCALE		REV
	09/78 78060 - A - 124	



MATERIAL BALANCE 1
GAS PLANT
32
26
25
C_5^-
NAPHTA STABILIZATION
AND SPLITTING
530
170⁻
81
C_5/80
LIGH
SH
H_2
C_2^-
C_3/C_4
104
80/170
320
CATALYTIC
REFORMER
262
KE
HYDR
335
170/220
645
220/300
645
300/370
CRUDE
5000
ATMOSPHERIC CRUDE DISTILLATION
2845
370⁺
SECTION 1

MATERIAL BALANCE 10^3 T/YEAR



SECTION 2

81

49	FUEL GAS
34	LPG
81	LIGHT GASOLINE SR
104	HEAVY GASOLINE SR
262	REFORMATE
335	KEROSENE SR
645	LIGHT GAS OIL SR
645	HEAVY GAS OIL SR
2845	ATMOSPHERIC RESIDUUM

0

0

335

SECTION 3

belcip
DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY
REFINING SCHEME N° 1

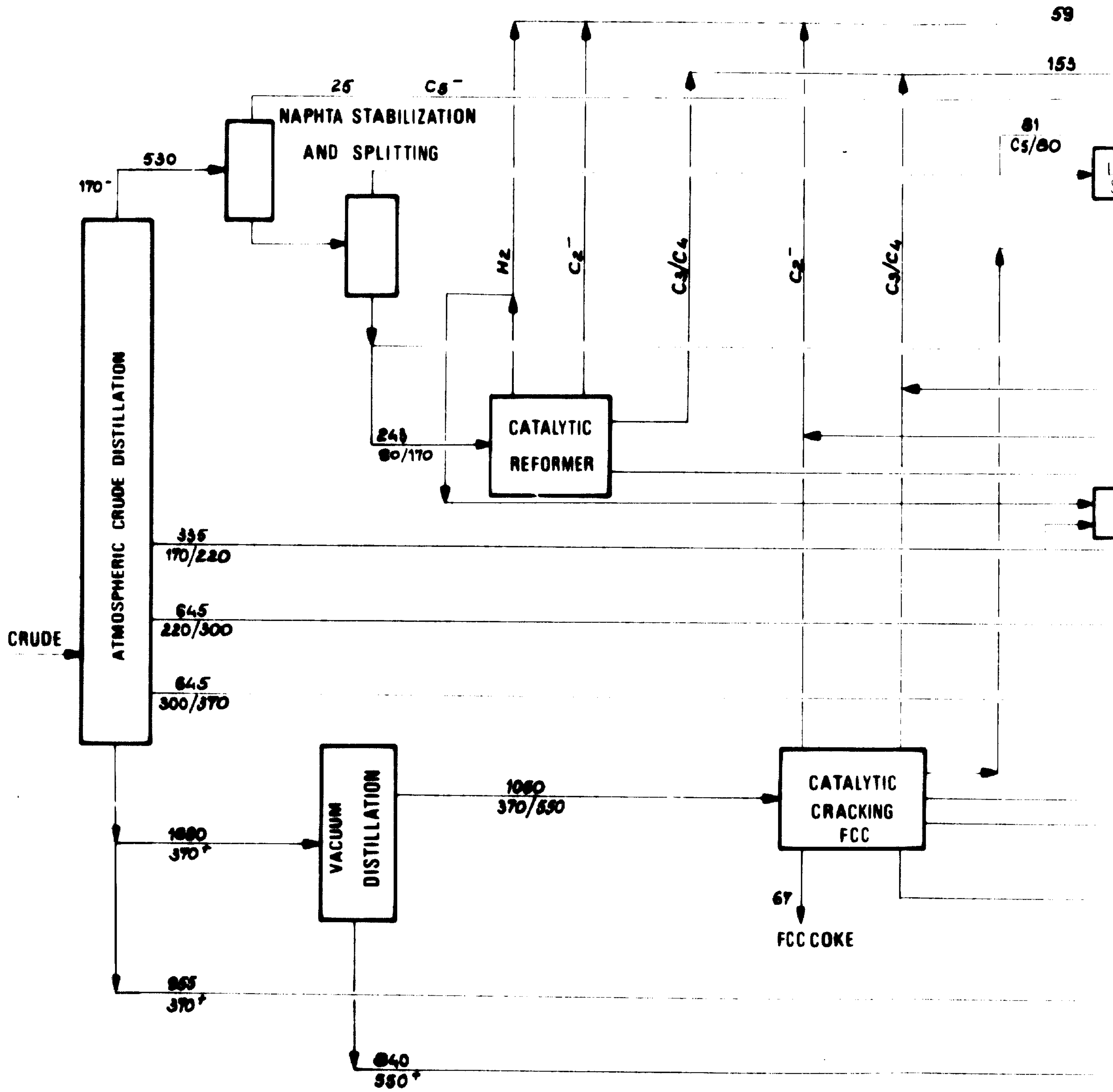
100% MINAS CRUDE DESIGN BASIS

SCALE

09/78 78060 A 131

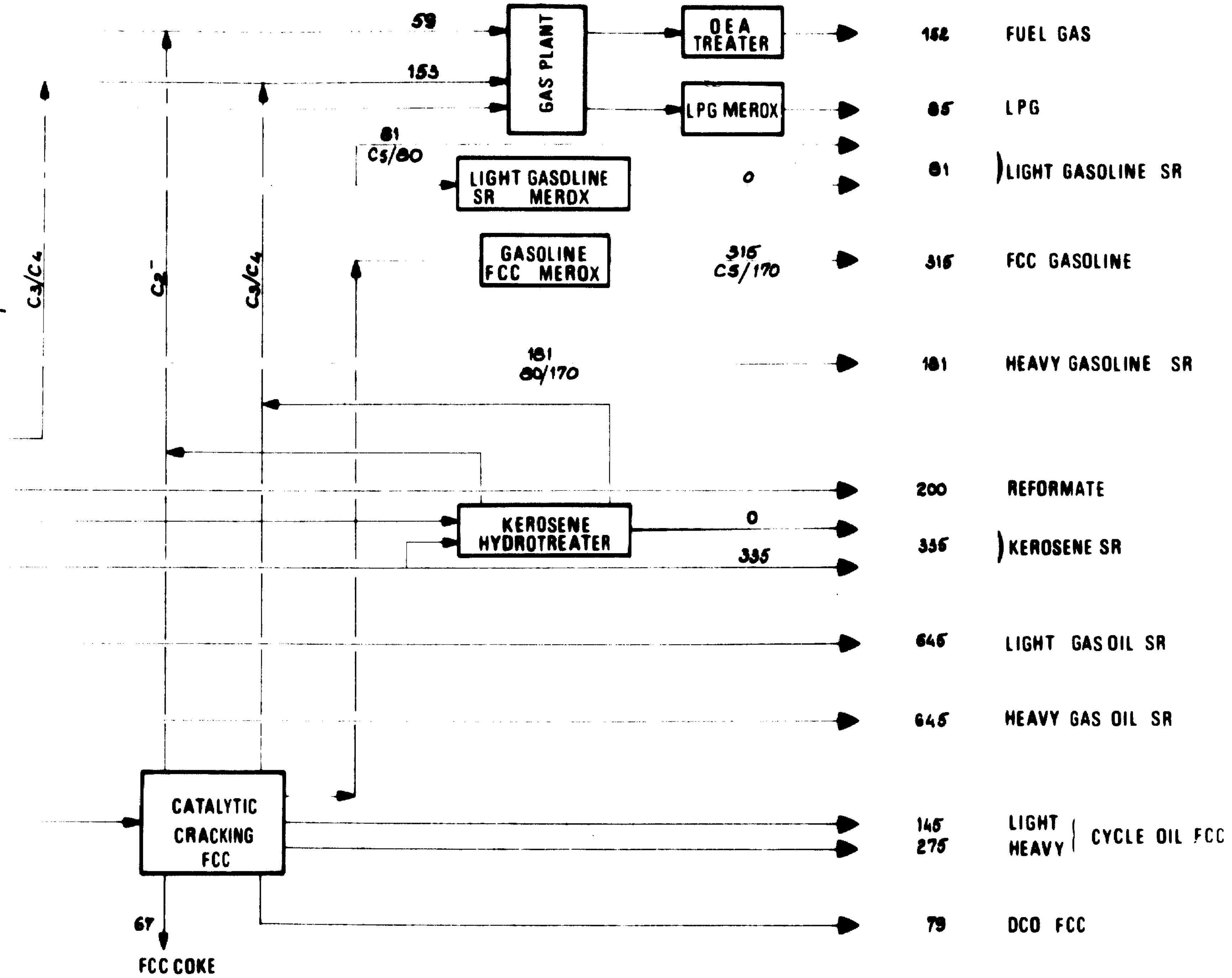
REV.

MATERIAL BALANCE 1

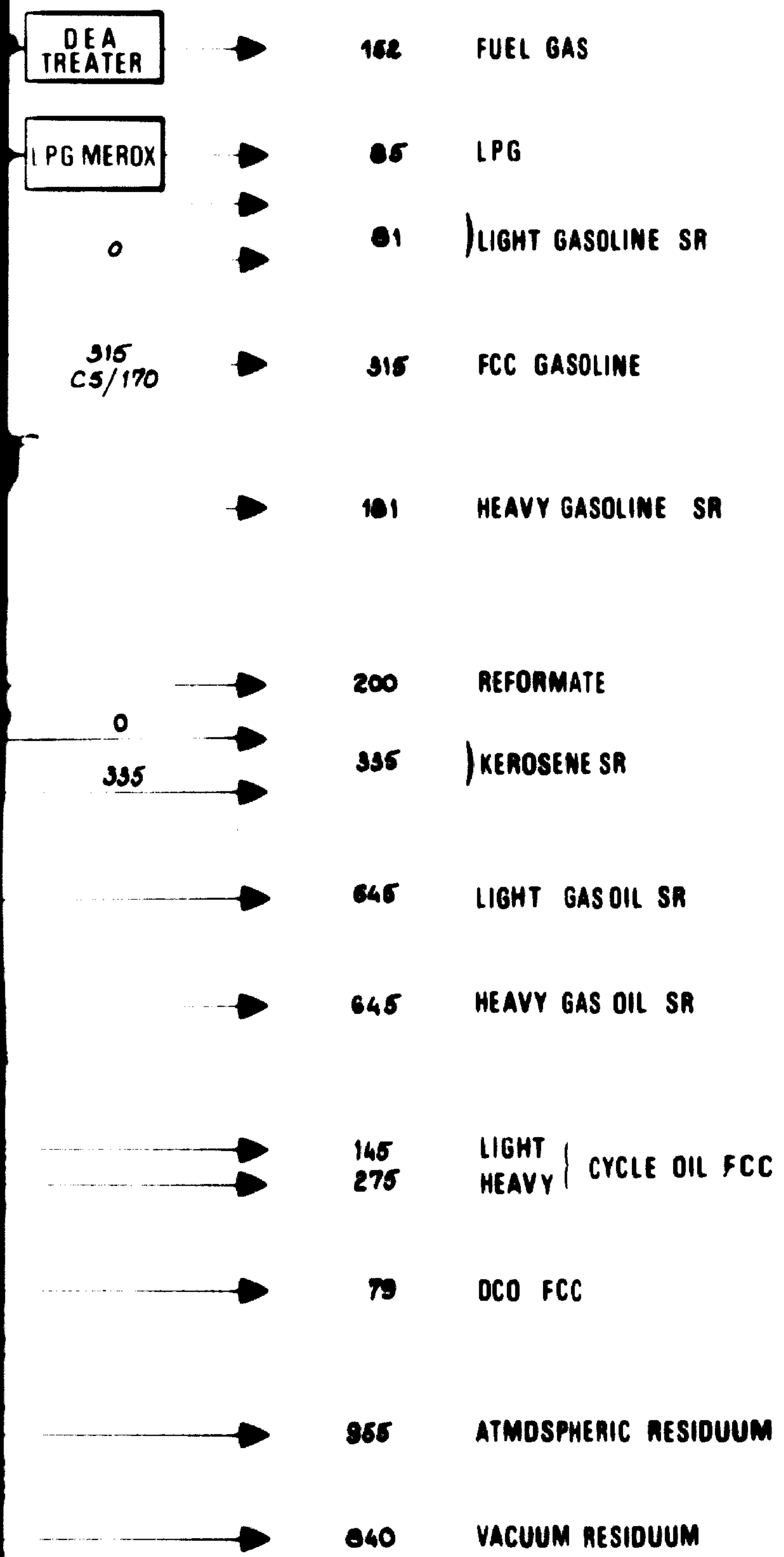


SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2



SECTION 3

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DIVISION DES ÉTUDES INDUSTRIELLES

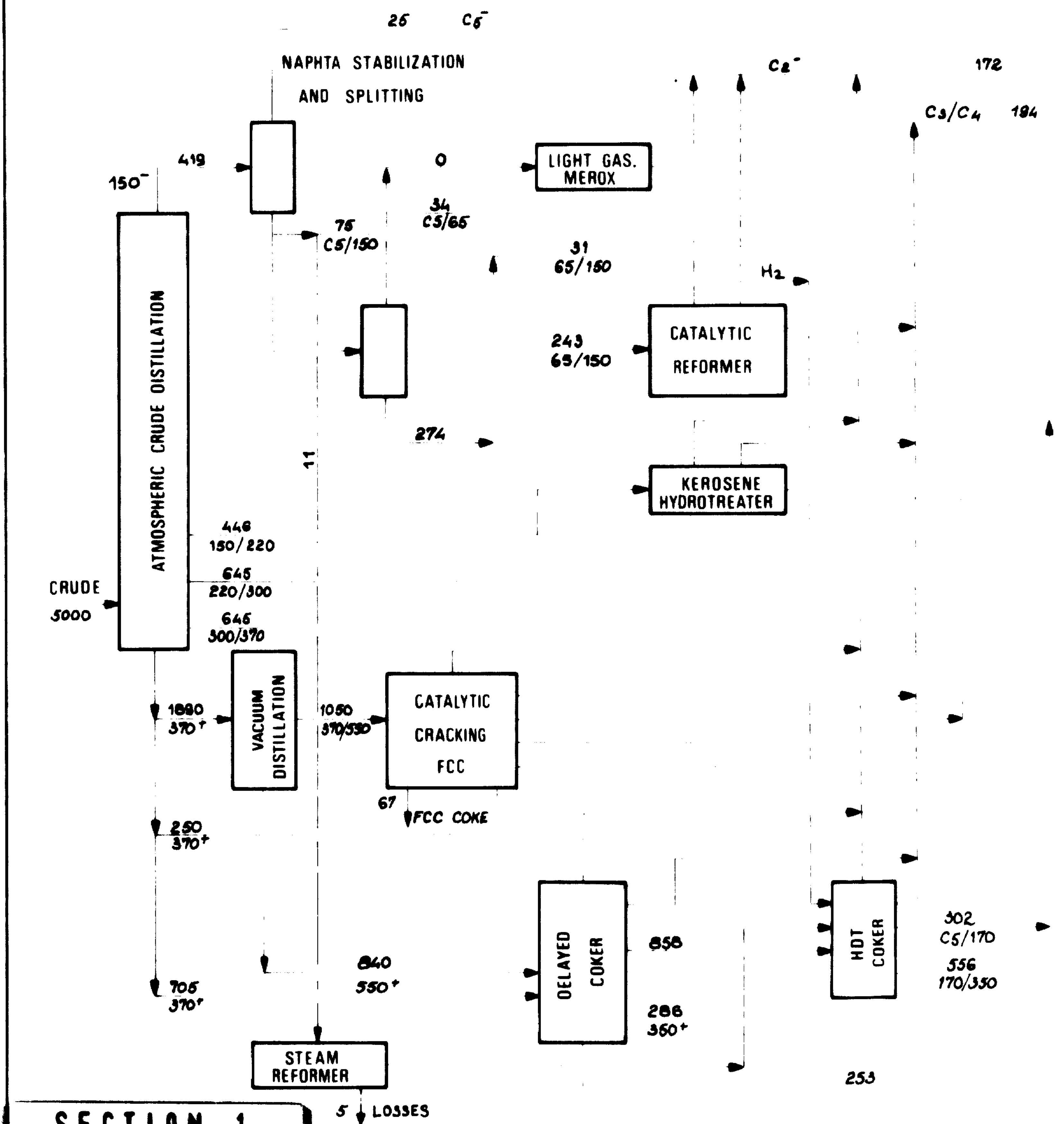
PETROVIETNAM REFINERY

REFINING SCHEME N°2

100% MINAS CRUDE DESIGN BASIS

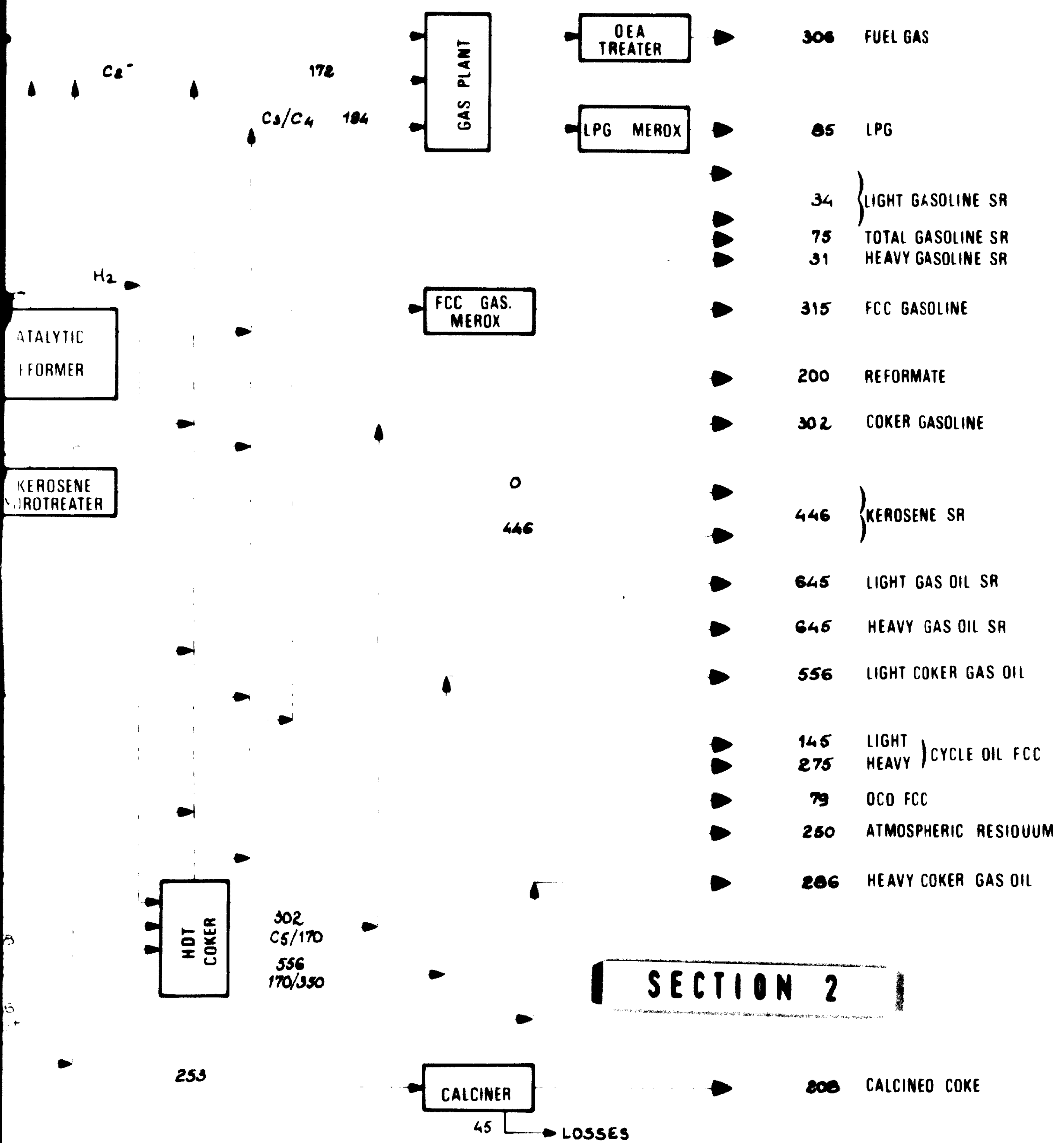
SCALE :		REV
	09/78 78060 - A - 132	

MATERIAL BALANCE 1C



SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

DEA TREATER

PG MEROX

306	FUEL GAS
85	LPG
34	LIGHT GASOLINE SR
75	TOTAL GASOLINE SR
31	HEAVY GASOLINE SR
315	FCC GASOLINE
200	REFORMATE
302	COKER GASOLINE
446	KEROSENE SR
645	LIGHT GAS OIL SR
646	HEAVY GAS OIL SR
556	LIGHT COKER GAS OIL
145	LIGHT CYCLE OIL FCC
275	HEAVY CYCLE OIL FCC
79	DCO FCC
250	ATMOSPHERIC RESIDUUM
286	HEAVY COKER GAS OIL
808	CALCINED COKE

SES

SECTION 3

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DIVISION DES ÉTUDES INDUSTRIELLES

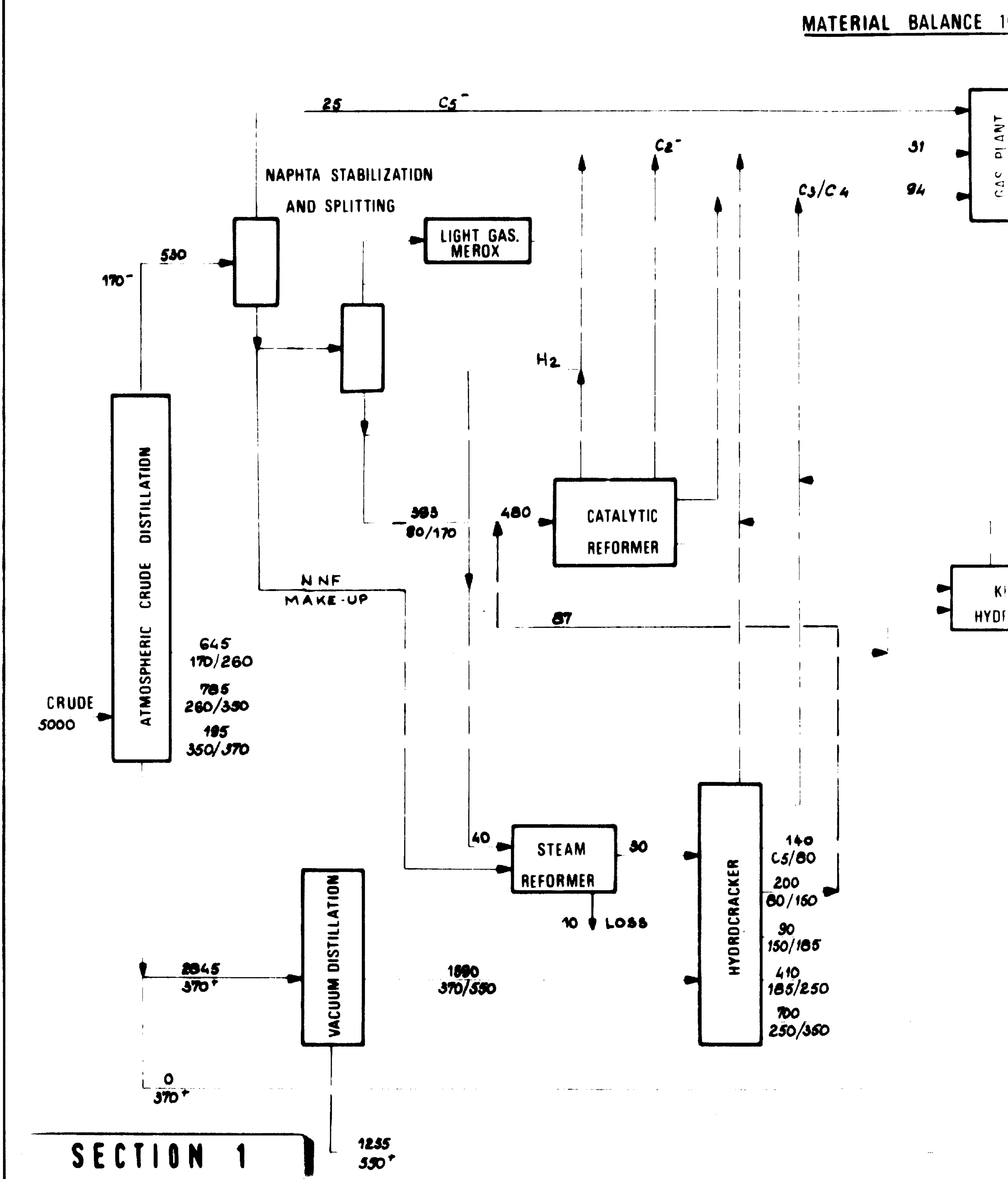
PETROVIETNAM REFINERY
REFINING SCHEME N°3

100% MINAS CRUDE DESIGN BASIS

SCALE

09/78 78060 A-133

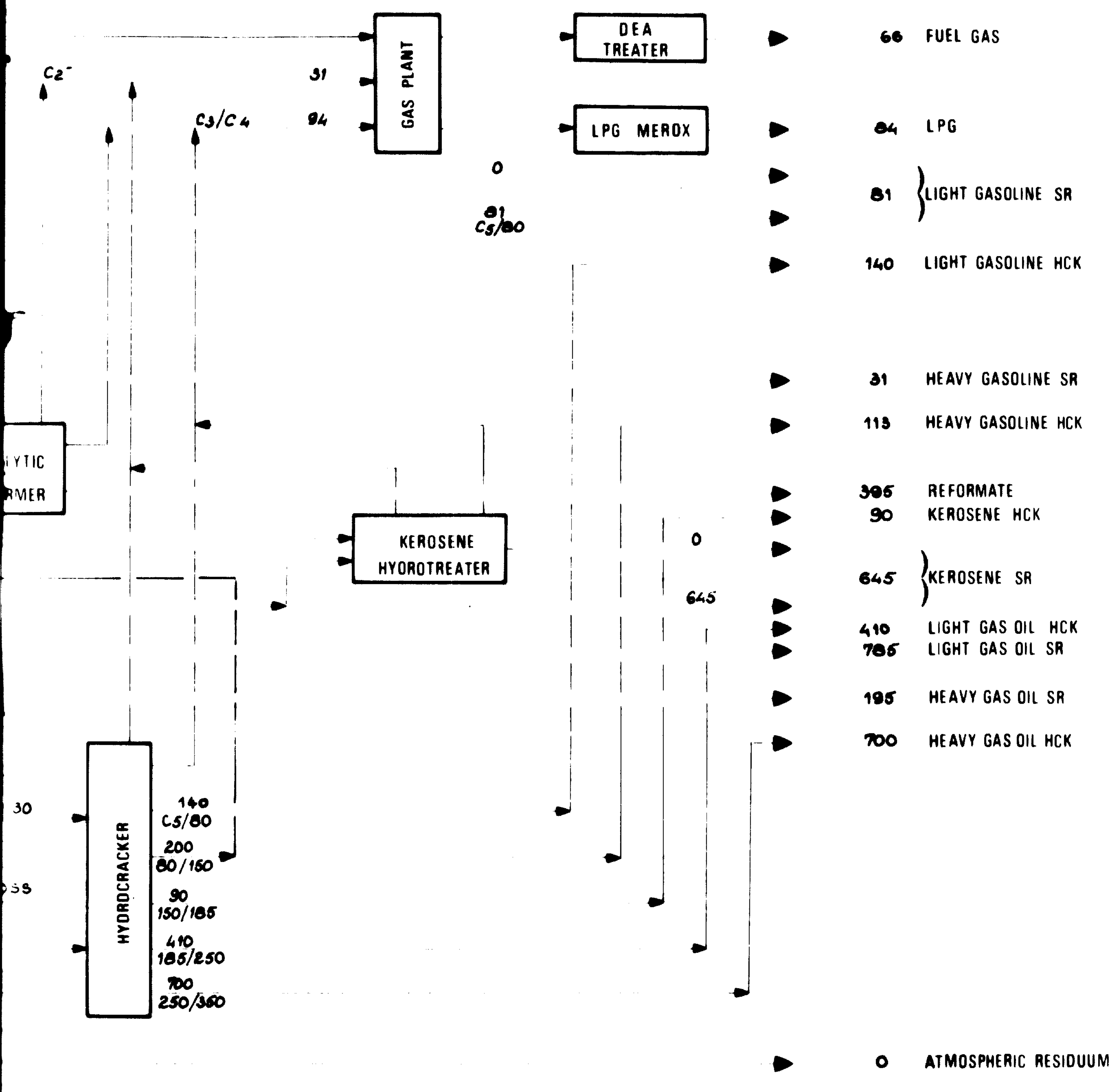
REV



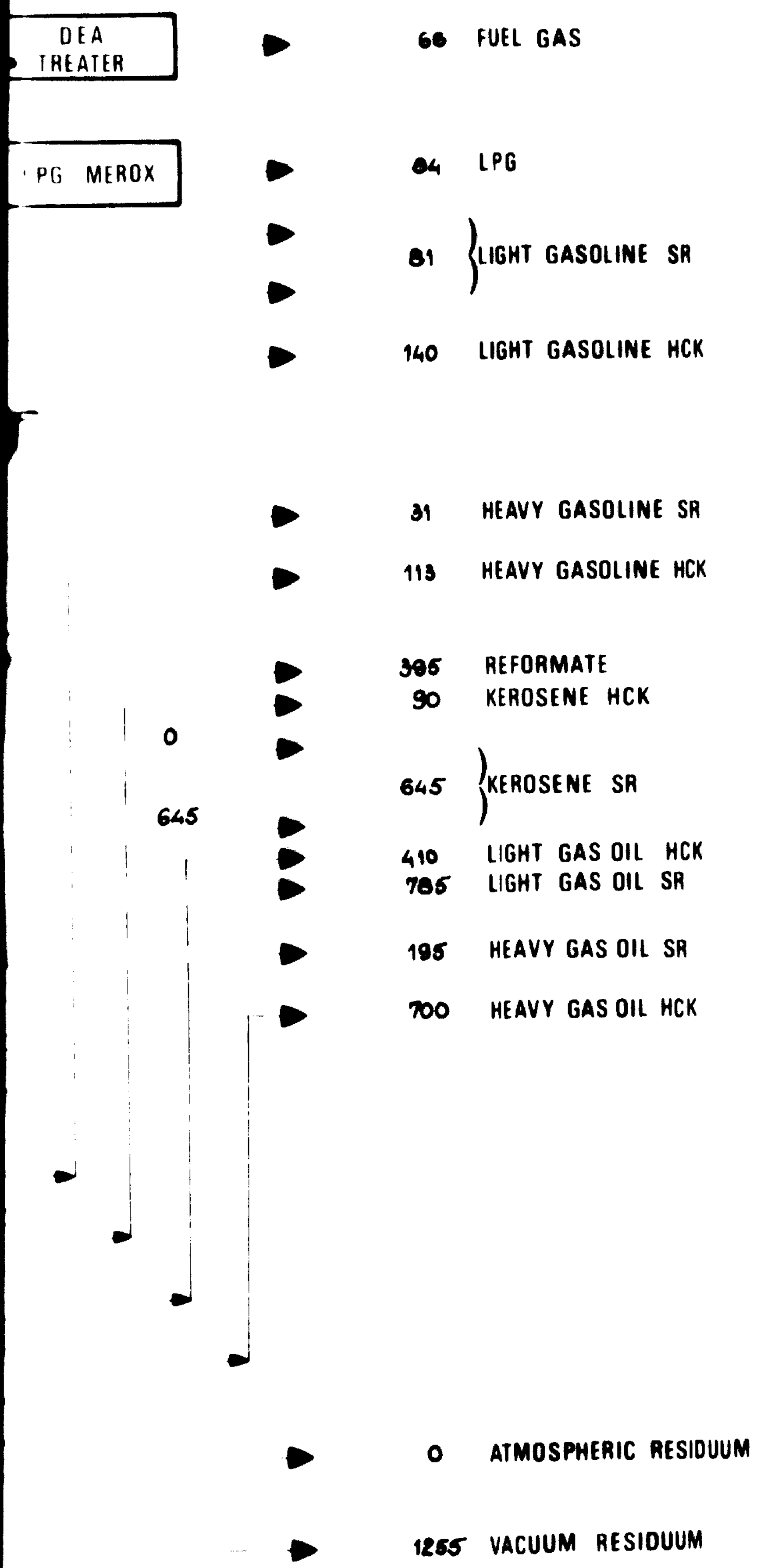
MATERIAL BALANCE
25
C_5^-
C_2^-
NAPHTA STABILIZATION
AND SPLITTING
C_3/C_4
31
94
LIGHT GAS. MEROX
530
170⁻
H_2
ATMOSPHERIC CRUDE DISTILLATION
385
80/170
480
CATALYTIC REFORMER
NNF MAKE-UP
87
645
170/260
785
260/350
185
350/370
CRUDE
5000
40
STEAM REFORMER
30
10
LOSS
HYDROCRACKER
140
C5/80
200
80/150
90
150/185
410
185/250
700
250/350
2845
370⁺
VACUUM DISTILLATION
1880
370/550
0
370⁺
1235
550⁺

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2



SECTION 3

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DIVISION DES ÉTUDES INDUSTRIELLES

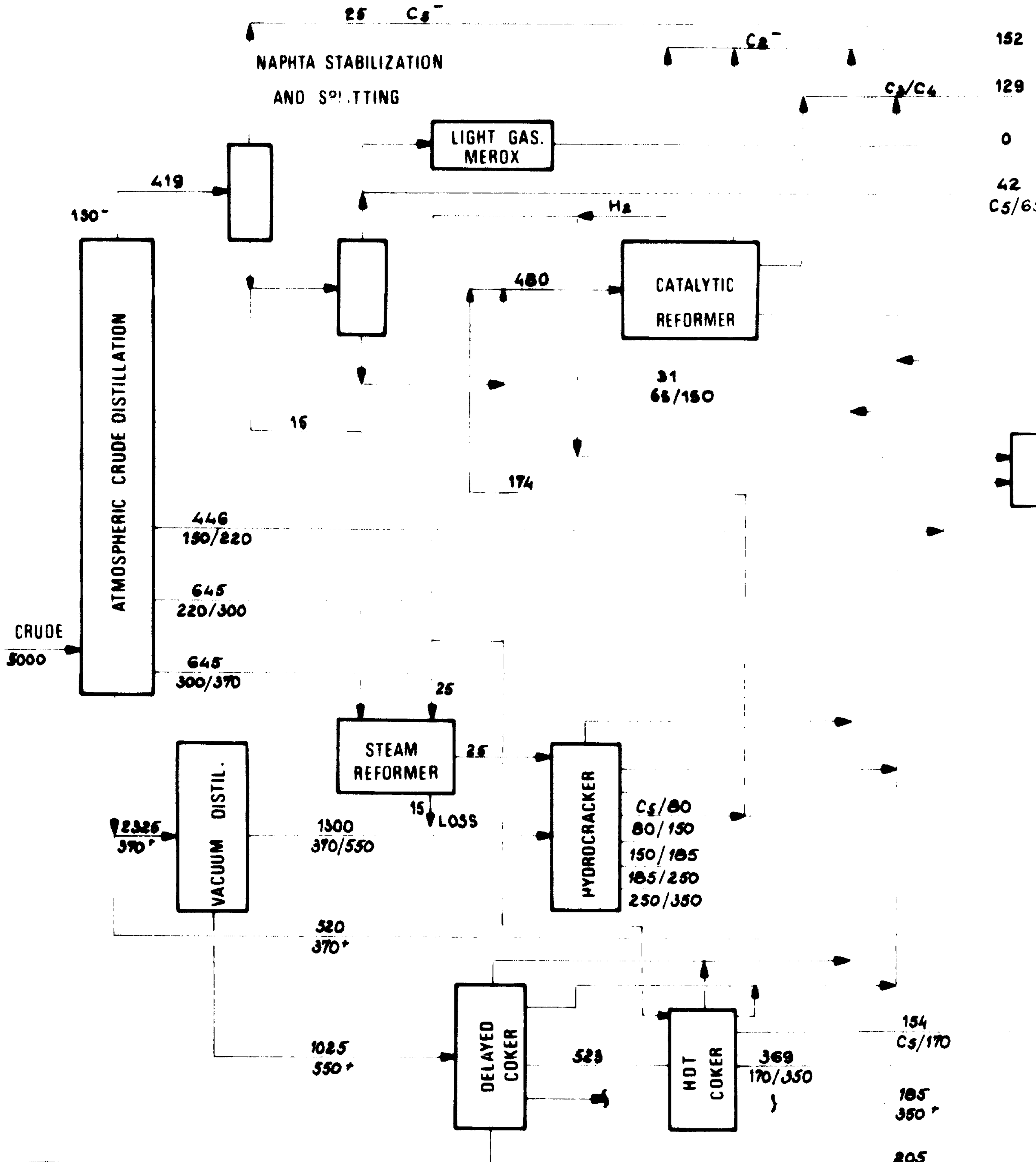
PETROVIETNAM REFINERY

REFINING SCHEME N°4

100% MINAS CRUDE DESIGN BASIS

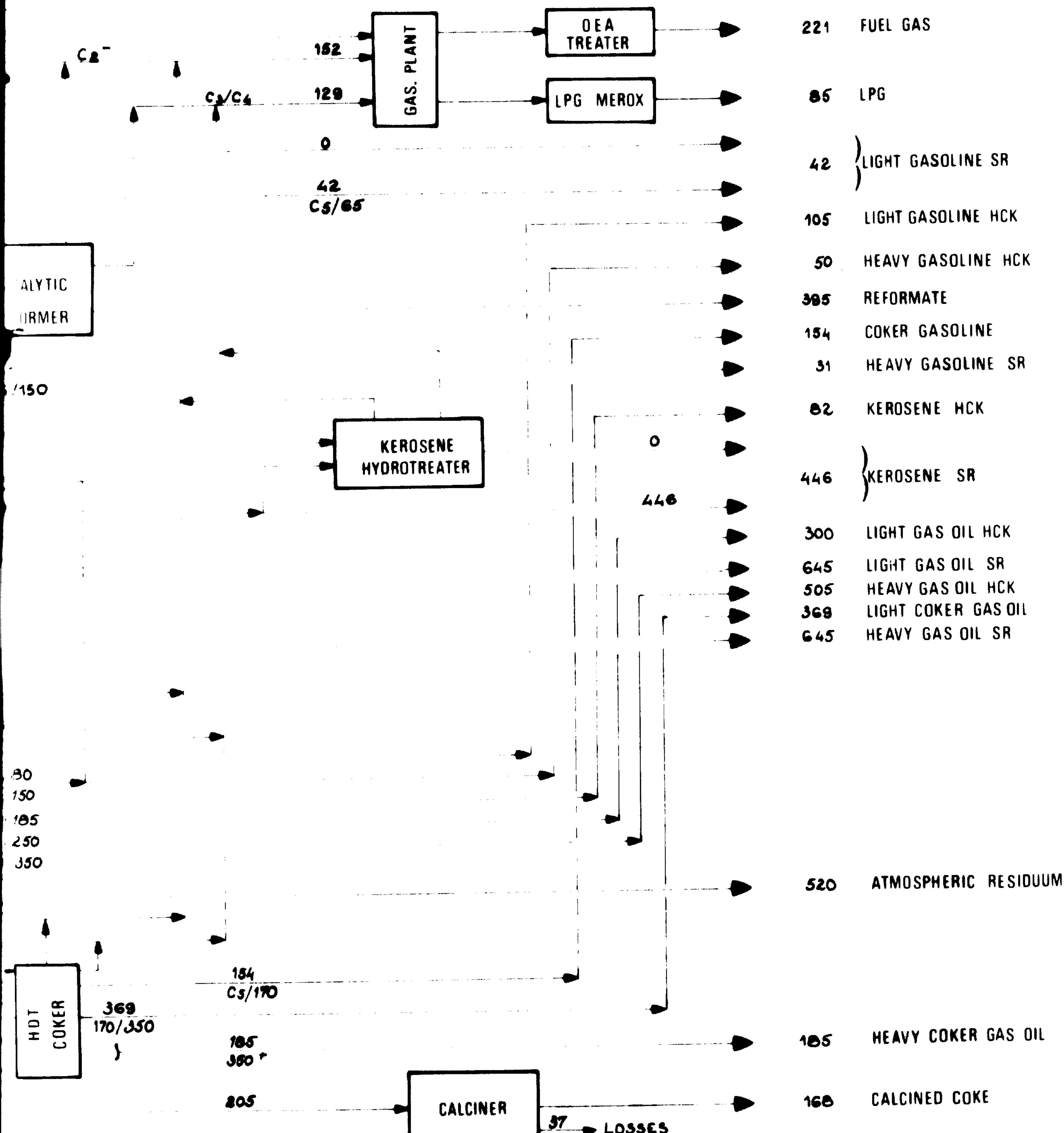
SCALE :		REV
	09/78 78060 - A - 134	

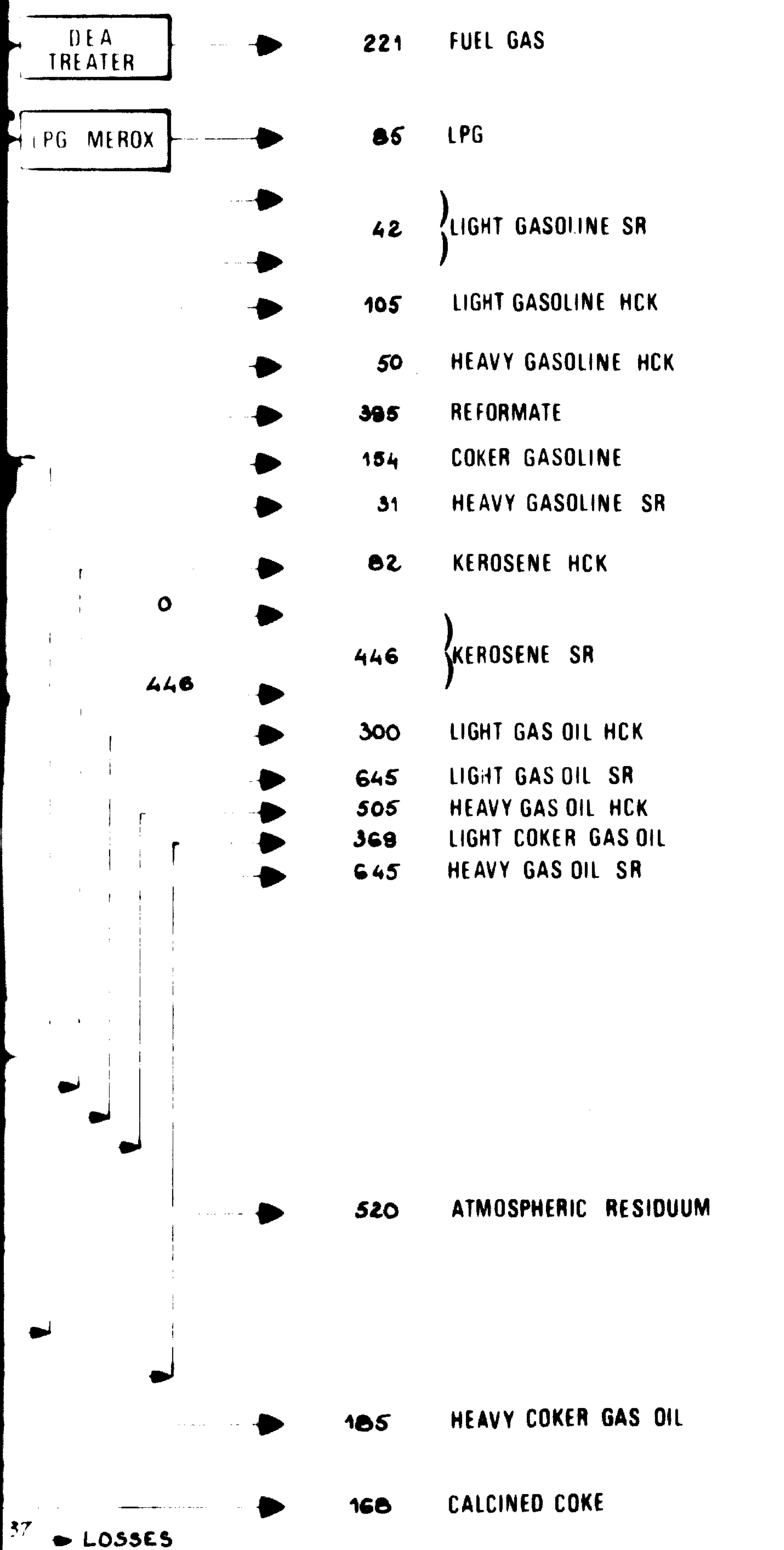
MATERIAL BALANCE



SECTION 1

MATERIAL BALANCE 10^3 T / YEAR





SECTION 3

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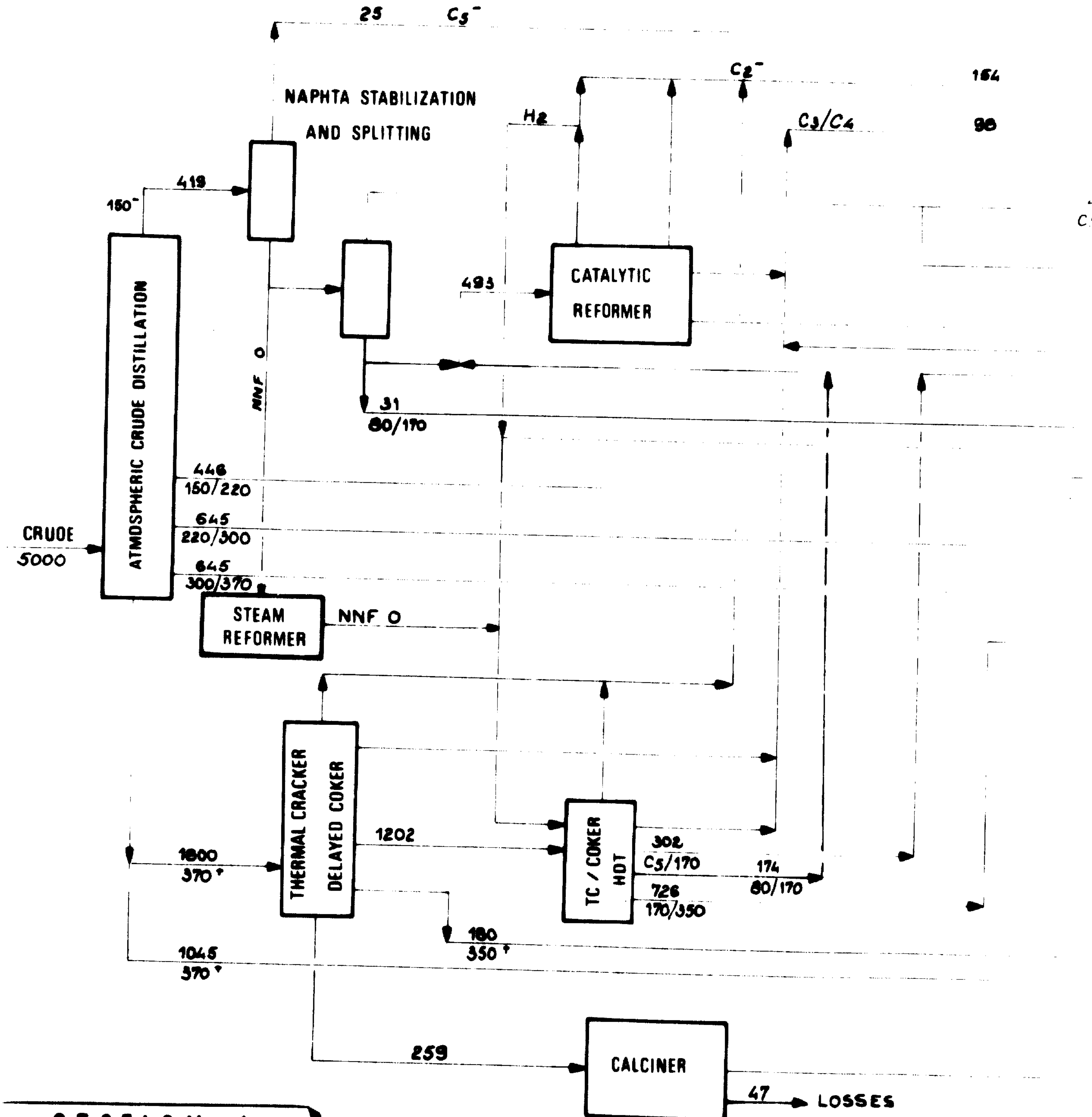
DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY
REFINING SCHEME N° 5

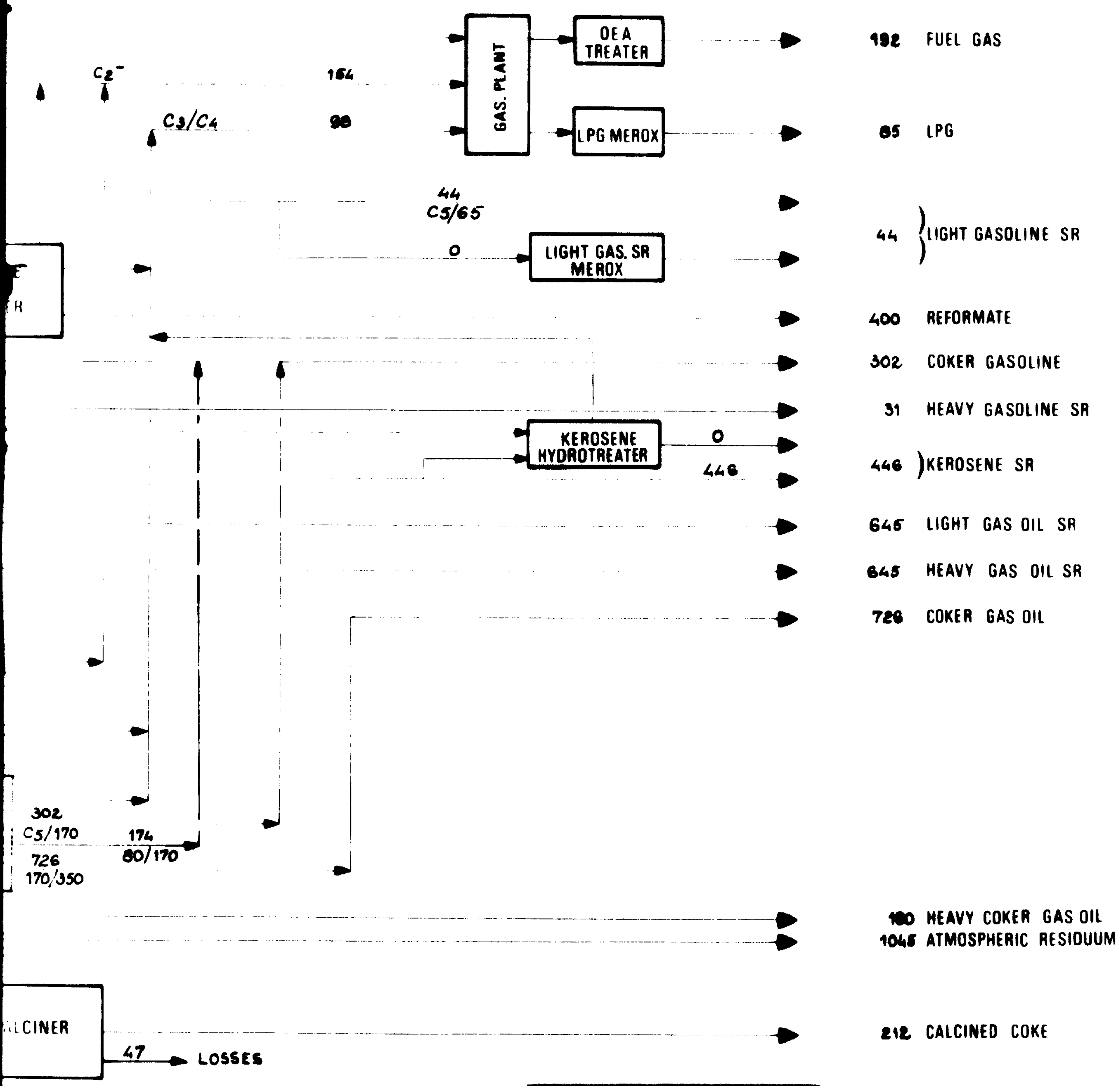
100% MINAS CRUDE DESIGN BASIS

SCALE		REV
	09/78 78060 - A - 135	

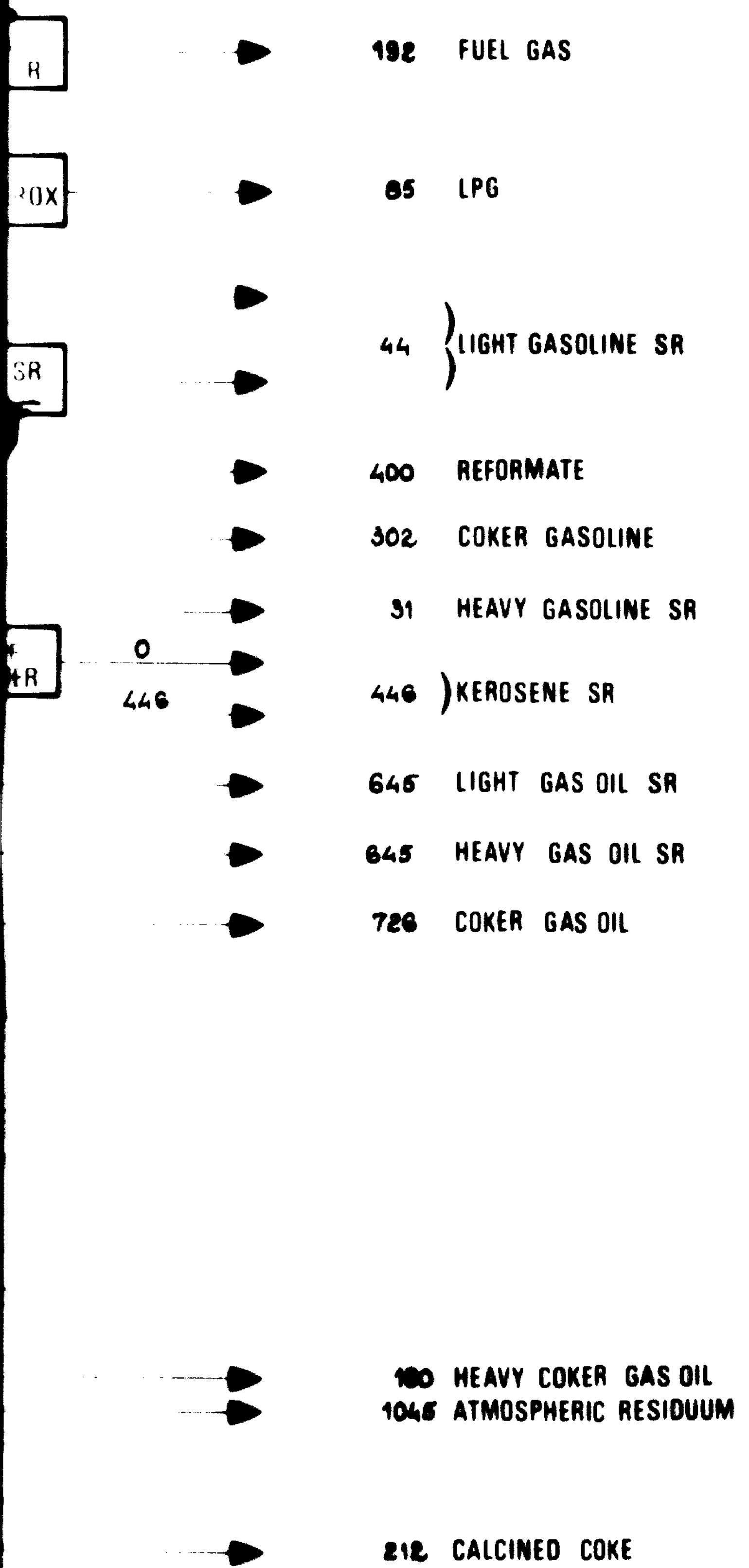

25
C_5^-
NAPHTA STABILIZATION
AND SPLITTING
C_2^-
154
H_2
C_3/C_4
98
150⁻
419
ATMOSPHERIC CRUDE DISTILLATION
NNF O
493
CATALYTIC
REFORMER
31
80/170
446
150/220
645
220/300
645
300/370
CRUDE
5000
STEAM
REFORMER
NNF O
THERMAL CRACKER
DELAYED COKER
1800
370⁺
1202
TC / COKER
HDT
302
C_5/170
174
80/170
726
170/350
180
350⁺
1045
370⁺
259
CALCINER
47
LOSSES

SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2



SECTION 3

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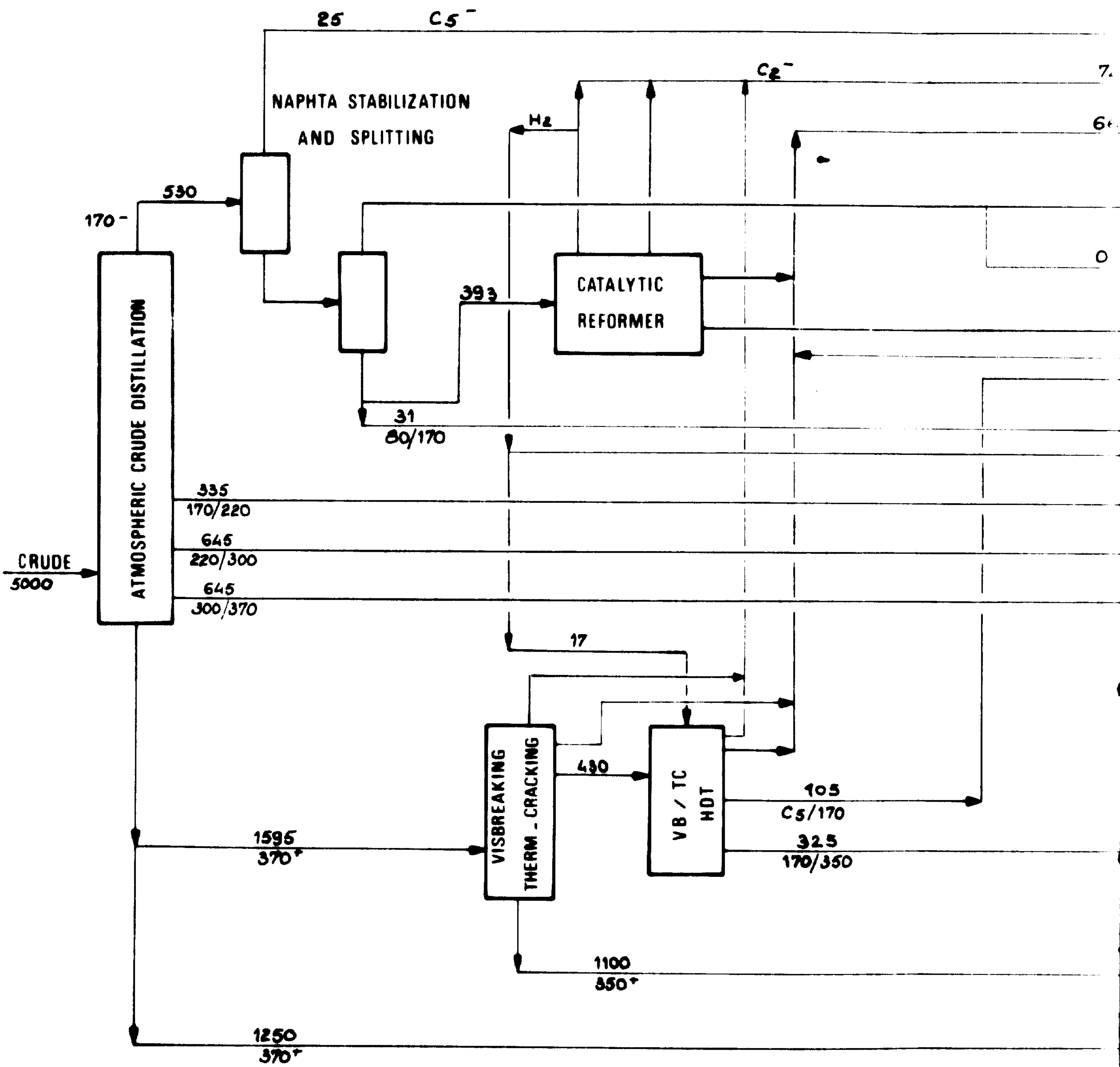
DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY
REFINING SCHEME N°6

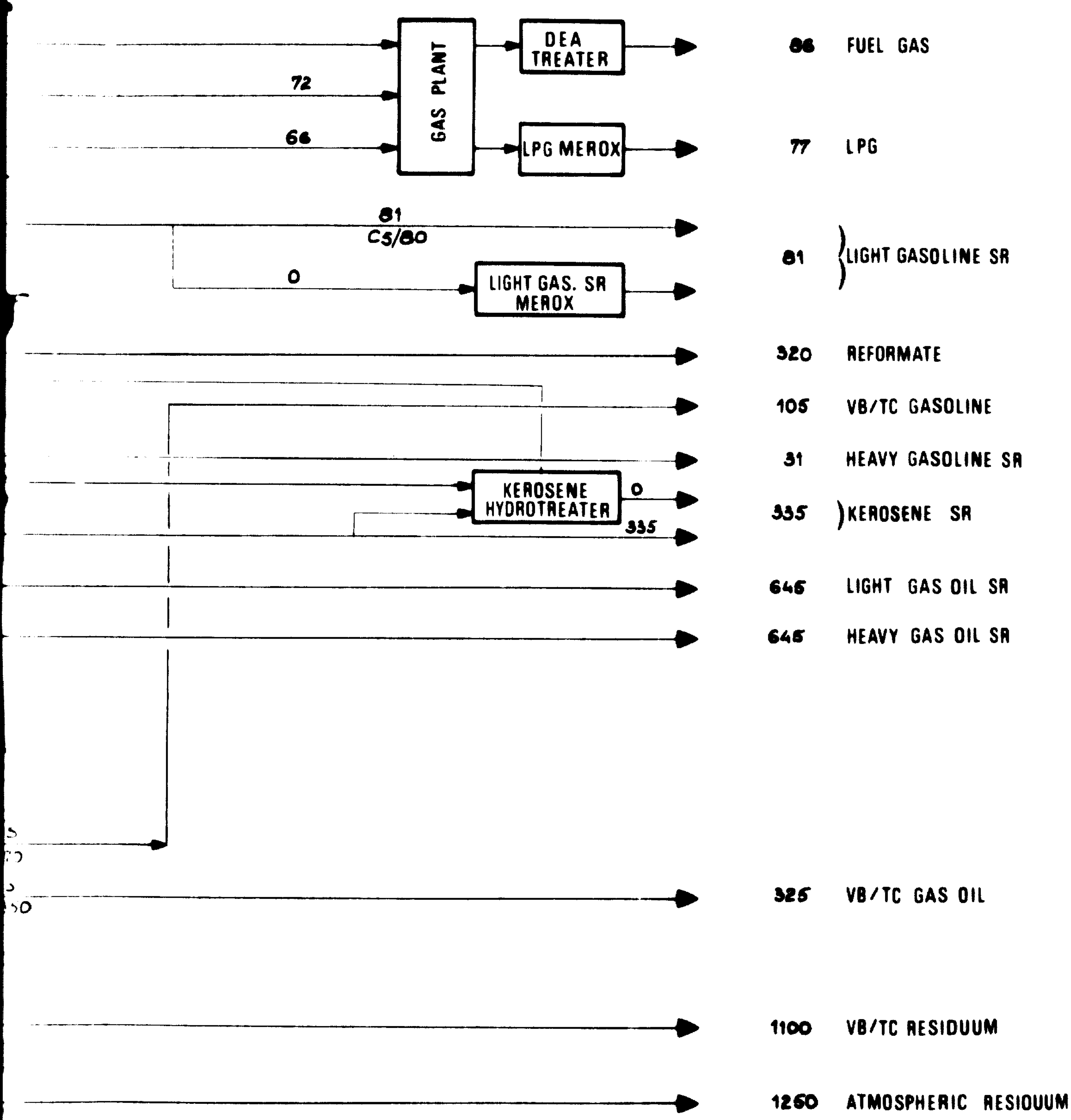
100% MINAS CRUDE DESIGN BASIS

SCALE :		REV.
	09/78 78060 - A - 136	


25
C5 -
C2 -
7.
NAPHTA STABILIZATION
AND SPLITTING
H2
6
530
170 -
O
CATALYTIC
REFORMER
393
ATMOSPHERIC CRUDE DISTILLATION
31
80/170
335
170/220
CRUDE
5000
645
220/300
645
300/370
17
VISBREAKING
THERM_CRACKING
430
VB / TC
HDT
405
C5/170
1595
370+
325
170/350
1100
350+
1250
370+

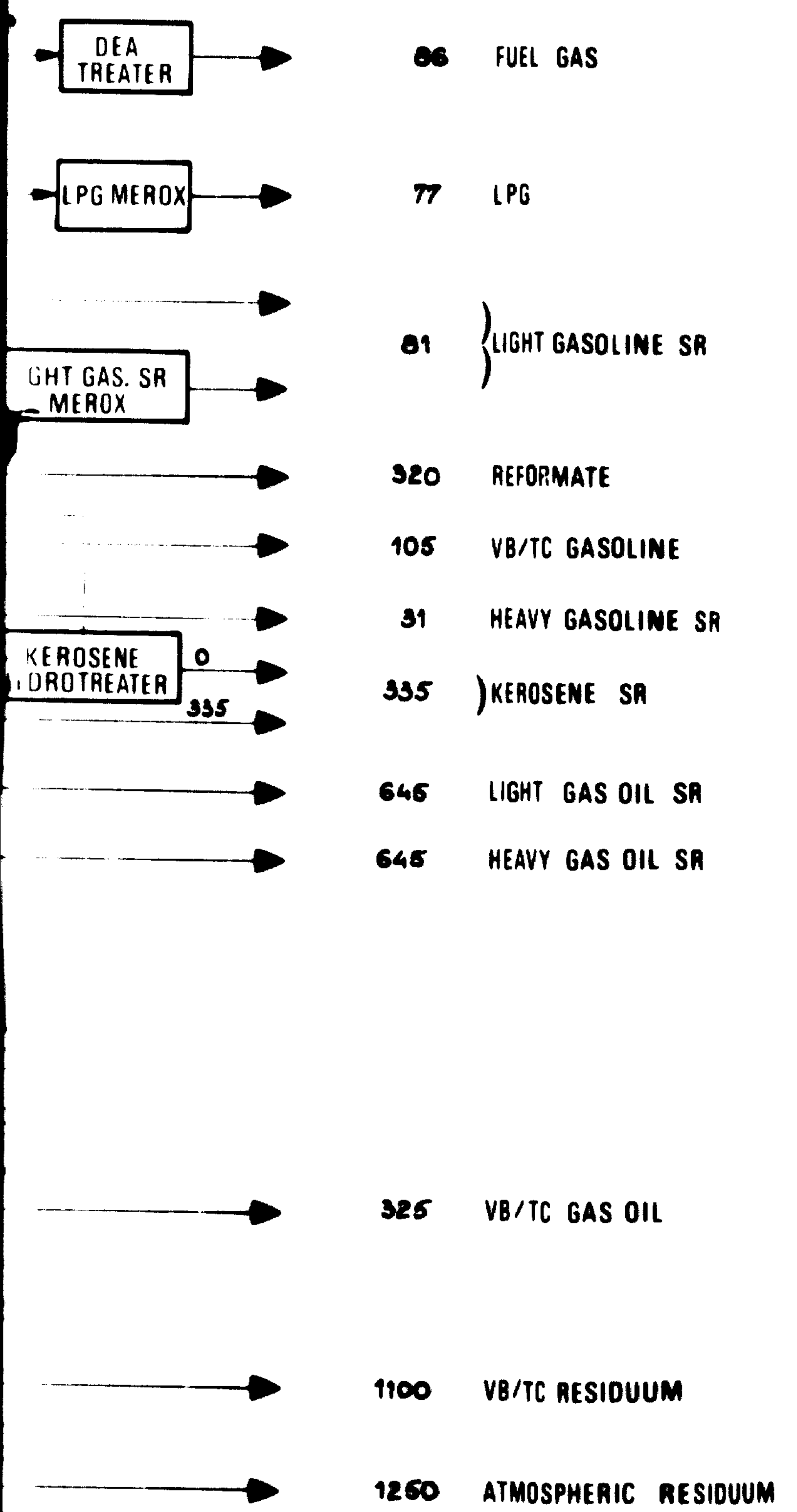
SECTION 1

MATERIAL BALANCE 10^3 T / YEAR



SECTION 2

SCALE



SECTION 3

b e i c i p
DIVISION DES ÉTUDES INDUSTRIELLES

PETROVIETNAM REFINERY
REFINING SCHEME N° 7

100% MINAS CRUDE DESIGN BASIS

SCALE :

03/78 78060 - A - 137

REV.

[illegible]

C-105

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