5.2 Victoria Plant

In order to achieve the required specifications for gasoline and diesel oil, only the brown coal hydrogenation is required. The combination with a Fischer-Tropsch synthesis is therefore not necessary.

The drawing No. 1-1-00/01 illustrates the technological interrelations of the major process plants

- Brown coal storage and crushing
- Flash drying and slurry preparation
- Slurry drying and slurry pretreatment
- Coal hydrogenation and vacuum distillation
- Hydrogen production
- Working-up of the primary coal oil
- Waste water purification

Not shown on the overall block flow diagram are the integrated auxiliary units, such as power plant, oxygen plant, etc.

The raw brown coal is stored in a below-grade bunker. From this bunker the raw brown coal is transported by belt conveyors to the crushing station. The crushed brown coal is carried by belt conveyors to the power plant and to the coal drying station. The dried brown coal with a residual moisture of 12 % is transported from the flash drying station to the storage bunkers for dried coal.

The preparation of the coal oil slurry requires slurrying oil which is recovered as overhead product from the vacuum distillation of the hydrogenation residue and as bottom product from the atmospheric distillation of the primary coal oil.

Before the coal oil slurry is charged to hydrogenation final drying of the brown coal takes place in the form of a slurry drying. The dried slurry is subjected to thermal pretreatment to prevent the depositing of solids in the hydrogenation reactors.

Following the thermal pertreatment of the slurry the catalyst and the co-catalyst are added.

Slurry preparation is arranged in two trains while slurry drying, slurry pretreatment and coal hydrogenation comprise four parallel trains. One hydrogenation train chiefly consists of 4 series - connected hydrogenation reactors, the last reactor being followed by the hot separator.

After separation in the hot separator the bottom product is routed via further separators to vacuum distillation. The vacuum residue is supplied to gasification in the Texaco gasifiers.

The gas phase from the hot separator, after passing through heat exchangers, is cooled further. The condensed liquid phase is recovered from cold separators and constitutes after separation from the aqueous phase the oil phase which is charged to atmospheric distillation.

The gaseous phase from the cold separator is largely freed of non-condensed hydrocarbons by oil wash. The so obtained impure hydrogen is used as recycled hydrogen in the hydrogenation reactors.

Arranged upstream of the atmospheric distillation are three large tanks for the separation of the remaining reaction water. In the distillation unit the coal oil is separated by distillation into a naphtha fraction and a middle oil fraction. Both fractions are stored in the tank farm before further processing. The atmospheric distillation bottom product is used as slurrying oil and is equally stored in the tank farm.

Middle oil and naphtha are hydrotreated to remove oxygen, nitrogen and sulphur bearing compounds. The product from middle oil hydrotreating boiling in the range from 180 - 320°C is saleable diesel oil and is supplied to the tank farm. Hydrotreating of the middle oil also involves parallel hydrocracking reactions. A naphtha fraction is, therefore, recovered in the distillation unit arranged downstream of the middle oil hydrotreating. This naphtha, together with the naphtha from atmospheric distillation, is subjected to hydrotreating. Subsequent distillation furnishes light gasoline fraction and heavy naphtha fraction. Light gasoline and heavy naphtha are stored in a tank farm. The heavy naphtha is treated by catalytic reforming.

Part of the refined middle oil is charged from the tank farm to a hydrocracker. The main products are light gasoline and naphtha.

The naphtha is supplied, together with the heavy naphtha from the naphtha hydrotreating unit, to the reformer mentioned earlier.

Reformate is recovered from the stabiliser arranged downstream of the reformer.

The catalytic reformer is followed by a gas fractionation unit where the hydrogen for the middle oil hydrocracker is recovered besides crude LPG and fuel gas.

The crude LPG from the middle oil and naphtha hydrotreater, together with the crude LPG from the middle oil hydrocracker and from the gas fractionation unit mentioned above, are charged to a distillation unit for separation into two fractions. The distillation bottom product serves for setting the gasoline vapour pressure. The overhead product consisting mainly of propane is supplied to the tank farm. It can be used to compensate fluctuations in the fuel gas consumption/fuel gas production.

The lean gas and rich gas from high pressure hydrogenation, together with the non-condensate gases from the atmospheric distillation of the middle oil and naphtha hydrotreating plants, are used for hydrogen manufacture or as fuel gas. The lean gas is preferably employed for hydrogen production in the steam reformer. Two parallel steam reformer units have been provided.

All other surplus process off-gases are desulphurised and used as fuel gas, together with the sulphur-free gases from the middle oil hydrocracker and the gas fractionation unit arranged after the reformer.

The steam reforming unit furnishes about 50 % of the hydrogen requirements. The balance being covered from the gasification of vacuum residue in 5 Texaco gasifiers. The raw gas from Texaco gasification is treated in 5 parallel-arranged shift converters before it enters the desulphurisation and CO_2 removal units. The hydrogen, together with the hydrogen from steam reforming, is supplied to a central compressor station where it is compressed to 340 bar for coal hydrogenation, to 220 bar for middle oil hydrotreating and to 110 bar for naphtha hydrotreating.

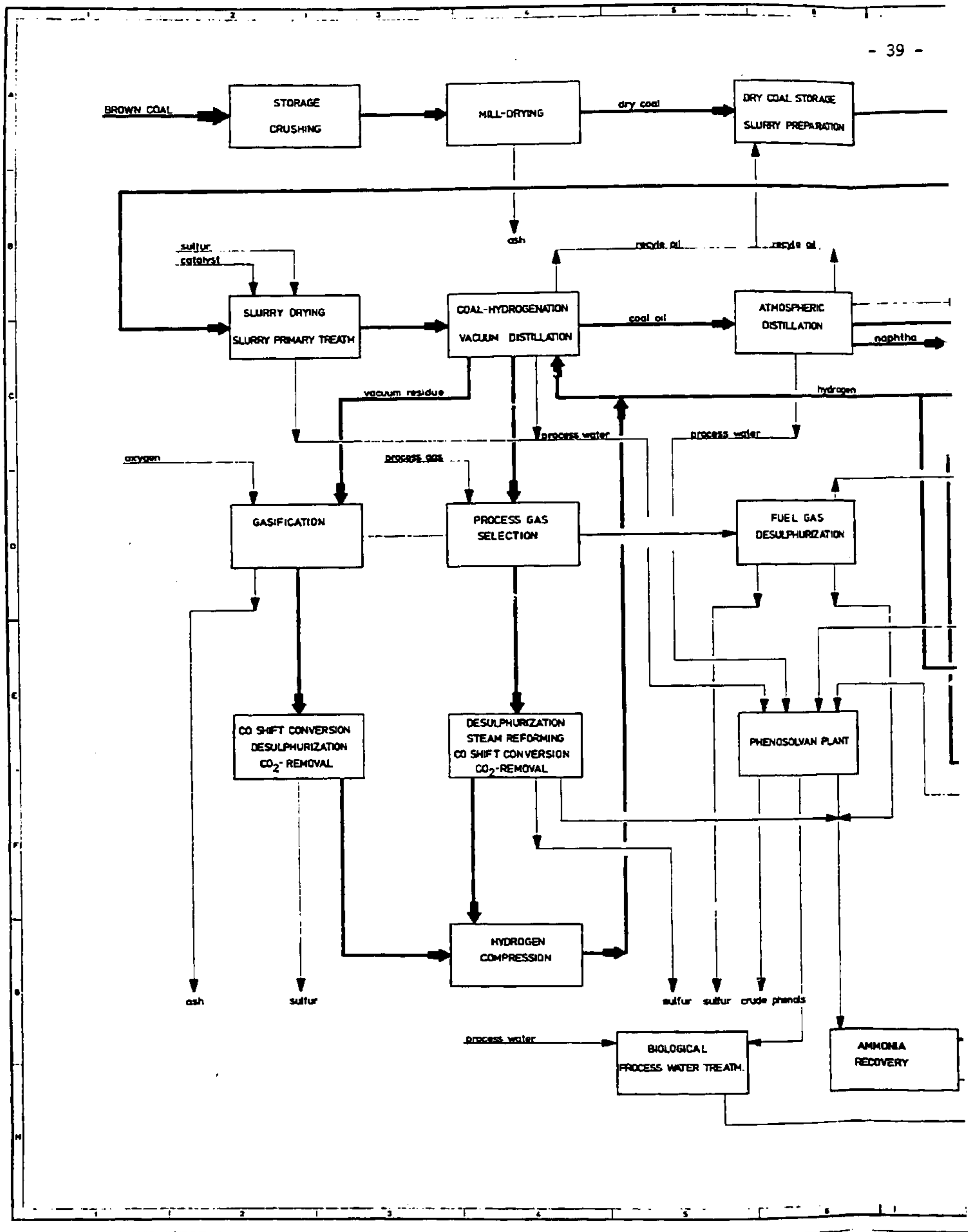
All waste water containing phenol is treated in a phenosolvan unit. The covered crude phenols are returned to high pressure hydrogenation. The pretreated effluents are sent, together with other process effluents mainly from coal oil working-up, to a biological treatment plant.

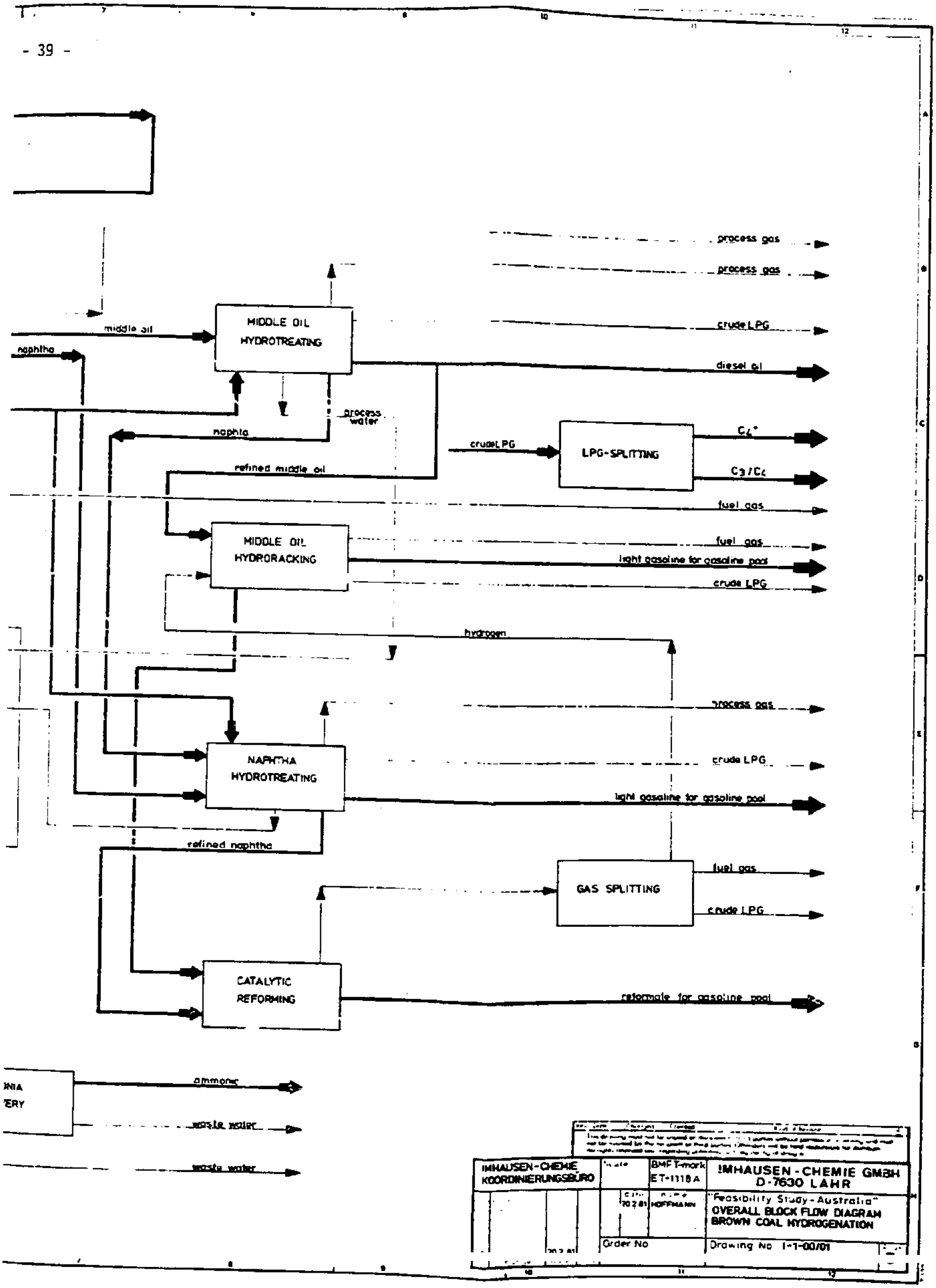
Waste water from steam reforming and from fuel gas desulphurisation containing ammonia are treated in an ammonia recovery plant. The effluent from ammonia recovery having a residual ammonia content of maximum 100 ppm is discharged to the sewer, together with the waste water from biological treatment.

The sulphur recovery plants produce sulphur with high purity. The major portion of this sulphur is recirculated as co-catalyst.

The other salt-bearing but not chemically polluted waste water streams from Texaco gasification, cooling towers, boiler feed water preparation, steam boiler blow-down and the flush water from the brown coal drying unit can be discharged separately and used, for instance, for the preparation of a pumpable ash-water slurry.

The tank farm is amply dimensioned for the storage of intermediate products so that temporary failures of up-stream or downstream units can be overcome. A blending station is provided for the preparation of different gasoline grades. The tank farm for liquefied gases comprises 10 spherical tanks which permit the storage of sufficient quantities of external liquefied gas for start-up operation. The capacity of the tanks for slurrying oil is sufficient for storing the external slurrying oil for the start-up of the plant.


BROWN COAL
STORAGE
CRUSHING
MILL-DRYING
dry coal
DRY COAL STORAGE
SLURRY PREPARATION
ash
sulfur
catalyst
recycle oil
recycle oil
SLURRY DRYING
SLURRY PRIMARY TREATM
COAL-HYDROGENATION
VACUUM DISTILLATION
coal oil
ATMOSPHERIC
DISTILLATION
naphtha
vacuum residue
hydrogen
process water
process water
oxygen
process gas
GASIFICATION
PROCESS GAS
SELECTION
FUEL GAS
DESULPHURIZATION
CO SHIFT CONVERSION
DESULPHURIZATION
CO_2- REMOVAL
DESULPHURIZATION
STEAM REFORMING
CO SHIFT CONVERSION
CO_2-REMOVAL
PHENOSOLVAN PLANT
HYDROGEN
COMPRESSION
ash
sulfur
sulfur
sulfur
crude phenols
process water
BIOLOGICAL
PROCESS WATER TREATM.
AMMONIA
RECOVERY


process gas
process gas
crude LPG
middle oil
MIDDLE OIL
HYDROTREATING
naphtha
diesel oil
process water
naphta
crude LPG
LPG-SPLITTING
C_4^+
C_3/C_4
refined middle oil
fuel gas
MIDDLE OIL
HYDROCRACKING
fuel gas
light gasoline for gasoline pool
crude LPG
hydrogen
process gas
NAPHTHA
HYDROTREATING
crude LPG
light gasoline for gasoline pool
refined naphtha
GAS SPLITTING
fuel gas
crude LPG
CATALYTIC
REFORMING
reformate for gasoline pool
ammonia
waste water
waste water
IMHAUSEN-CHEMIE
KOORDINIERUNGSBÜRO
BMFT-mark
ET-1118 A
IMHAUSEN-CHEMIE GMBH
D-7630 LAHR
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HOFFMANN
"Feasibility Study-Australia"
OVERALL BLOCK FLOW DIAGRAM
BROWN COAL HYDROGENATION
Order No
Drawing No 1-1-00/01

6. Planned and Reached Production, and Product Qualities

The attached Table 4 shows the planned and reached production of the three plants in New South Wales, Queensland and Victoria.

The main difference is the production of LPG. In the case of Victoria the main amount of LPG is used as fuel gas. Only a small amount of 64 800 t/year of LPG is produced.

Table 5 shows the product qualities.

Table 4

t/a	New South Wales		Queensland		Victoria	
	planned	reached	planned	reached	planned	reached
Gasoline	1,500,000	1,517,680	1,500,000	1,517,600	2,000,000	1,896,392
Diesel	1,500,000	1,498,960	1,500,000	1,498,960	1,000,000	920,080
LPG	450,000max.	435,401	450,000max	400,430	-	64,800
S	-	57,472	-	40,568	-	26,480
NH_3	-	64,536	-	38,784	-	48,747
Sum	3,450,000	3,574,049	3,450,000	3,496,342	3,000,000	2,956,499

Table 5

		New South Wales		Queensland		Victoria	
Gasoline							
RON (+ 0.15 ml Tel/1)		50 %	97	60 %	97	70 %	99.2
RON (without Tel)						30 %	> 93
RON (lower 0.15 ml Tel/1)		50 %	92	40 %	92		
Density	kg/l	0.758		0.758		0.759	
Automotive Diesel Oil (ADO)							
Cetan index		> 50		> 50		> 50	
Density	kg/l	0.840		0.840		0.840	
LPG							
C_3	wt.%	85 - 95		85 - 95		85 - 95	
liquid NH_3	wt.%	99.9		99.9		99.9	
Sulfur	wt.%	99.9		99.9		99.9	

7. Coal and Water Requirements and Thermal Efficiency

All data are listed in Table 6

The total input of the plants covers not only the coal for hydrogenation and gasification but also the coal for the power station.

The overall thermal efficiency of the plants has been determined by calculating the ratio of the total energy (in GJ, LHV) available in the motor fuels (gasoline and ADO) and LPG to the total energy supplied to the plant as coal.

Table 6

			New South Wales	Queensland	Victoria
Coal input, total		t/a	10,245,920 (mf)	10,113,040 (mf)	28,632,000
Coal input	GJ	(LHV)	294×10^6	281×10^6	258×10^6
Output, total		t/a	3,574,049	3,496,342	2,956,499
Output,	GJ	(LHV)	150.9×10^6	148.8×10^6	125×10^6
therm. efficiency			51.4 %	53.0 %	48.4 %
Fresh water		kl/a	45×10^6	47×10^6	26×10^6

8. Personnel Requirements for Operation, Repair and Maintenance

The labour requirements for operation, repair and maintenance are specified in detail for each of the process units or groups of process units at the beginning of the third year of operation.
These figures include also the supervision personnel for all process and off-site units as well as the manpower for

central laboratories
central workshop
canteen
central store
fire brigade
first aid station and

all general facilities such as electric power distribution system, connecting piping system etc.

During the period of plant start-up, i.e. the first two years of operation, the labour requirements are considered to be larger.
The major personnel requirements for operation and maintenance during this period are estimated to be :

10 % higer in the 1. operational year
5 % higher in the 2. operational year

The costs of the supervision manpower additionally required for start-up have been broken down in such a way that partly they are covered by start-up labour costs, partly by construction costs and engineering costs.

The Australian partner made use of the services of a personnel management consultant company in order to investigate the personnel requirement for the on-site plant administration. Based upon their findings the administration structure was broken down as follows :

personnel department	29 persons
finance & legal department	28 persons
technical research and development group	6 persons
public relations	1 person
Total	64 persons

To simplify cost estimation and to provide uniformity to the position description given by the different German companies in terms of the Australian trade and wages categories the Australian partner classified the labour requirements for the operation and maintenance from the third year after start-up :

Level	Typical classification	Number of persons NSW and QLD	Victoria
1	Top management	8	9
2	Superintendents	22	23
3	Engineers	93	118
4	Tradesmen	1943	1377
5	Unskilled workers	1026	614
	Total	3092	2141

9 Personnel Requirements for Construction Period

The requirement of personnel for the construction of the plant based on Australian conditions is 20 % higher than calculated for German conditions, so that according to the present schedule the peak requirement will be about 7,800 men for at least 24 months in New South Wales and Queensland and about 5,000 men in the Victorian case.

The total man-month requirement is approximately 190,000 in New South Wales and Queensland and 150,000 in Victoria, respectively.

The present schedule does not include the personnel for site preparation and levelling, the erection supervisory personnel and the general contractor's personnel for the overall organisation. The general contractor's personnel for the overall organisation is estimated at 5 % of the construction personnel on-site.

10. Energy Utilities - Off-Site Units

The differences in the data of electricity production, waste water, fuel gas and coal consumption for the power station are illustrated in following Table 7.

The Victorian plant needs no fuel gas production from coal because only about 65 000 t/a of LPG is recovered.

Table 7

		New South Wales	Queensland	Victoria
Electricity production	MW	422	370	480
Cooling water circulation	kl/a	$1388x10^6$	$1220x10^6$	$771x10^6$
Waste water	kl/a	$15.1x10^6$	$14.3x10^6$	$7.1x10^6$
Fuel gas from coal	GJ/a	$28.4x10^6$	$25.0x10^6$	-
Non chemical coal	t/a	$3.11x10^6$	$3.04x10^6$	$6.23x10^6$

11. Erection
Time Schedule

The following description is valid for each of the three plants in New South Wales, Queensland and Victoria.

In agreement with the Australian partner the 1st January, 1984, has been taken as the date for the start of the construction of a plant in Australia. The following statements and tables are based on this starting date. The construction period for the entire complex is 6 years which means that the plant can be put on stream on 1st January, 1990.
The individual phases of the construction period have been plotted in a lot of curves in the study. The construction period of 72 months is divided into phases which are briefly described hereinafter (see Fig. 3 "Time Schedule").

Phase I commences after the contract has become effective and includes the preparation of the entire engineering. 24 months are available for the completion of this work.

Phase II covers equipment requisition and procurement. In view of the long delivery time required for special items of machinery and equipment and in particular for power station equipment the first purchase orders shall be issued already in the 6th month. The delivery of all machinery and equipment will be completed in the 62nd month.

Phase III. This phase extends through 16 months reckoned from the effective date of the contract and includes infrastructural measures and the preparation of the site.

Phase IV. On completion of site preparation the civil work (foundations, etc.) is taken in hand in the 16th month. The civil work will be terminated at the end of the 60th month.

Phase V. The structural steelwork will commence in the 21st month and will be completed at the end of the 45th month.

Phase VI covers the actual erection work. The various activities have been scheduled as follows :

- Erection of equipment and machinery
  Start: 28th month - End: 71st month

- Erection of piping
  Start: 26th month - End: 72nd month

- Erection of electrical equipment
  Start: 21st month - End: 72nd month

- Erection of instruments and control
  Start: 22nd month – End: 72nd month

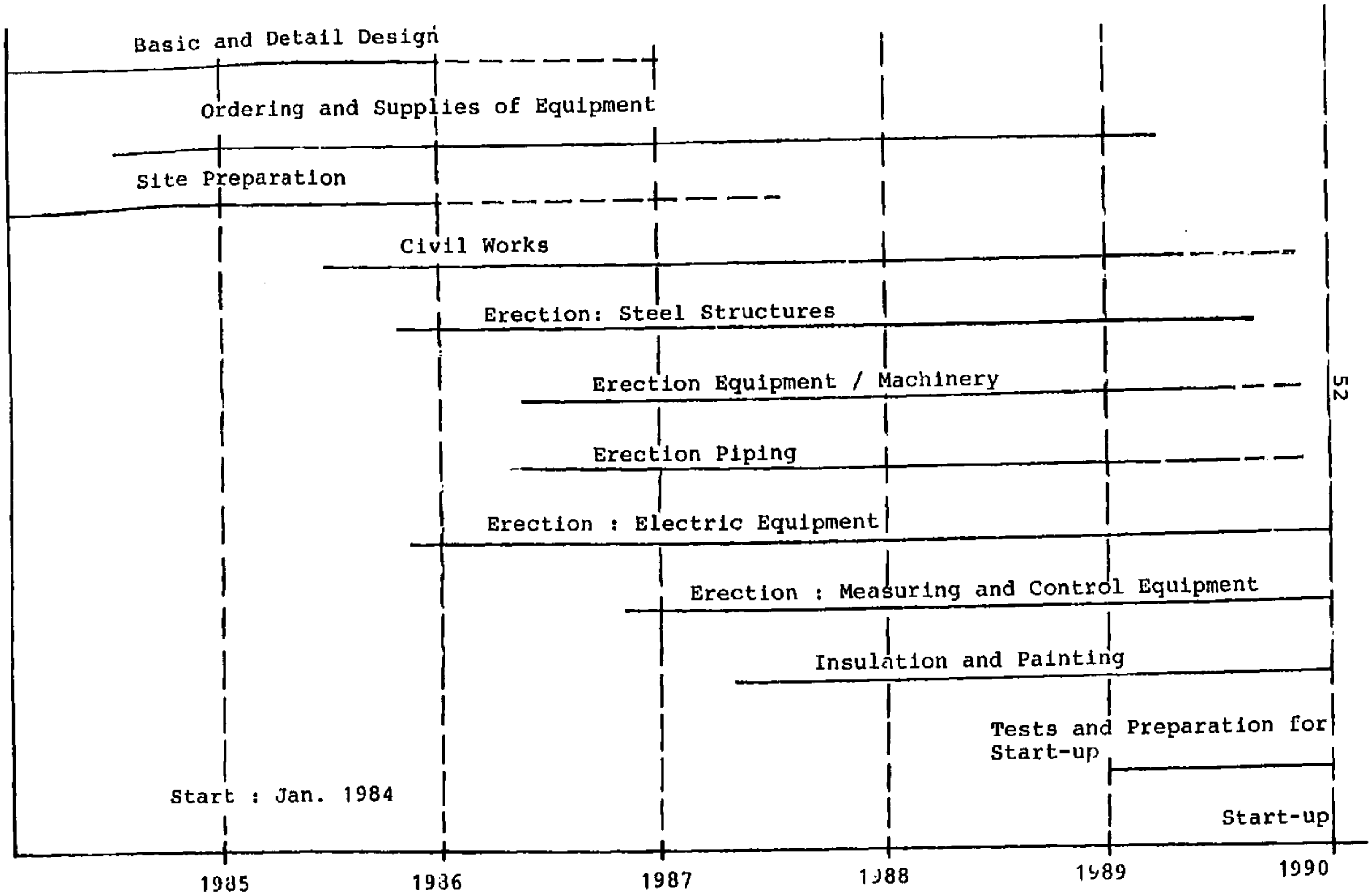
- Paintwork
  Start: 43rd month – End: 72nd month

- Insulation work
  Start: 41st month – End: 72nd month

The start-up of the plant begins after the 72nd month and extends through about 12 months.

The time schedule is based on the assumption that latest after 16 months the site is sufficiently prepared to permit starting of the construction work without fail.

Fig. 3 TIME SCHEDULE



12. Impact on Environment and Safety Facilities

General

The design of all process plants has been dased on the German environmental standards laid down in "TA-Luft" and "TA-Lärm" as well as on the all safety regulations and design rules which are valid for the equipment of the plant in question.

12.1 Safety Facilites

All substances discharged from safety valves (excepting steam, water, oxygen and nitrogen) will be routed to a closed blow-down, slop or flare system.

In the event of process failures and during start-up and shut-down of the plant the process streams can be safely discharged.

Process plants handling harmful products will be equipped with drip trays which in the event of leakages prevent the uncontrolled outflow of the products.

All product pumps are installed in pump houses or bunds, so that in the event of leakages the uncontrolled outflow of the products is also prevented.

The tank bunds are so sized that they can take the complete tank contents. In the normal case the drain pipes of the tank bunds are shut-off. In the event of rainfall the rainwater accumulated in the tank bund is discharged to the sewer after previous visual inspection.

The facilities for brown coal drying and dried coal conveying and storage are equipped with monitoring devices to measure the temperature and carbon monoxide and oxygen concentration. The dried coal transportation and storage system is protected against pressure surges and can be inertised when required. Moreover, all process plants are connected to the inert gas system.

The process plants and the tank farm are equipped with adequate fire fighting facilities. Foam is mainly used for the fire fighting of liquids and solids. Smothering steam or inert gas is employed for fire fighting in closed systems. Fire water is used for the cooling of structural steelwork, equipment and machinery. The fire water is supplied to the tapping points through underground pipelines. The tank farm includes 2 tanks to hold a supply of fire water.

An abundant supply of inert gas is ensured from the air separation plant.

All process areas are surrounded by roads so that prompt access for the fire trucks from the central fire brigade for fire fighting is ensured.

As the interconnecting piping and the supply lines are installed in open trenches the safety distances between the process plants are maintained in all cases.

12.2 Waste Water

The total amounts of the waste water are listed in Table 8. It is possible to collect the waste water streams in separate systems and to re-use for other purposes. Harmful matters are largely removed from the water in waste water treatment plants (see item 5.1, 5.2 and 13.).

12.3. Noise

The noise level of all high-noise coal grinders and other machines is reduced to the level allowed under the German standards by the provision of acoustic enclosures or by locating these machines in enclosed buildings.

The hydrogen compressors are low-speed reciprocsting machines emitting relatively littel noise. Besides, these machines, including all auxiliary equipment, are accommodated in a compressor house which prevents the radiation of noise to the environment.

the operators working in the compressor house are protected against excessive noise by the provision of sound-absorbing walls or the installation of a sound-proof room.

The noise impact from machinery (pumps, blowers, etc. including their drivers) installed in the open is minimised by the selection of suitable types and locations. Machinery installed outdoors will be provided with noise absorption hoods where necessary.

12.4 Gaseous Effluents

The major emissions of flue gases and process off-gases are listed in Table 8.

The flue gas streams from the combustion of fuel gas are discharged to atmosphere through stacks of different heights. The exclusive use of desulphurised fuel gas in all plants keeps SO_2 pollution at a very low level.

Before the waste gas from the Claus sulphur recovery plant is discharged to atmosphere it is routed through an incinerator where H_2S, COS, CS_2 and gaseous elemental sulphur are converted to SO_2 almost completely.

Only the Claus sulphur recovery plant has a higher output of SO_2. The impact on the environment could be reduced considerably by the provision of additional technical facilities.

According to information from the Australian side the flue gas from the power plants doesn't need to be desulphurised.

The other process plants do not discharge any waste gases containing H_2S, SO_2 or other toxic substances during normal operation. In the event of operational upsets the process waste gases can be discharged to atmosphere through flares equipped with ignition device, without creating any hazard.

The flue gases from the power plants shall be discharged to the atmosphere through stacks with different heights. The heights are :

New South Wales	275 m
Queensland	120 m
Victoria	260 m

12.5 Dust Emissions.

The flue gases from the power plants are cleaned in conventional dedusting facilities. The dust content is listed in Table 8.

The emissions occurring during the handling of the bituminous coal are confined locally by the roofing of the coal stockyard. The continuous natural ventilation across the entire hall lenght prevents the accumulation of explosive air mixtures. The dust is removed by water spraying or by exhausting so that there is no noteworthy environmental impact. Other dust bearing conveying and waste gases are dedusted in filter systems in accordance with the requirements of "TA-Luft" before they are dicharged to atmosphere.

The raw brown coal is supplied to the plant via belt conveyors where it is stored in below-grade bunker. Transportation of the raw brown coal from the storage bunker to the preparation plant is also by enclosed belt conveyors which can be sprayed with water in the event of local superheating. The transfer stations and the precrushing plant are equipped with exhaust facilities and pertinent filters. The maximum dust load of the flue gas from flash drying is 75 $mg/m^3{}_n$. All bunkers for the storage of the dried brown coal are provided with filter systems for the dedusting of the inert conveying gas before it is discharged to atmosphere. Water sprinklers have been provided to eliminate dust emission during periods of heavy sun radiation or wind.

Table 8

		New South Wales	Queensland	Victoria
Waste Water	m^3/h	1 840	1 748	860
Ash	t/a	2 717 440	2 459 000	870 400
Emissions				
Power Station	m_n^3/h	3 225 600	4 744 800	4 580 000
Dust	g/m^3	0.21	0.21	0.5
SO_2	vol.%	0.03	0.02	0.02
Brown coal crushing and mill drying	m_n^3/h	-	-	5 000 000
Dust	g/m^3	-	-	0.0075
SO_2	vol.%	-	-	0.01
Flue gas from process units where fuel gas is used	m_n^3/h	1 580 345	1 410 000	1 308 450
SO_2	"	17.0	25.1	3.48
Waste gases from Claus sulphur recovery and Stretford sulphur recovery plant	m_n^3/h	104 530	110 772	62 970
From Claus recovery plant SO_2	vol.%	0.9	0.79	0.38
From Stretford recovery plant H_2S	vol.ppm	9	6	
COS	vol.ppm	23	17	
CO_2 rich waste gases	m_n^3/h	452 098	437 719	463 407