4–3 UTILITY CENTER

In order to supply utilities necessary for operation of the ethylene, VCM, electrolysis, and HDPE plants[1] that are to be constructed as a petrochemical complex in Rayong, a utility center shall be constructed adjacent to the ethylene plant. The utility center shall be comprised of the following facilities:

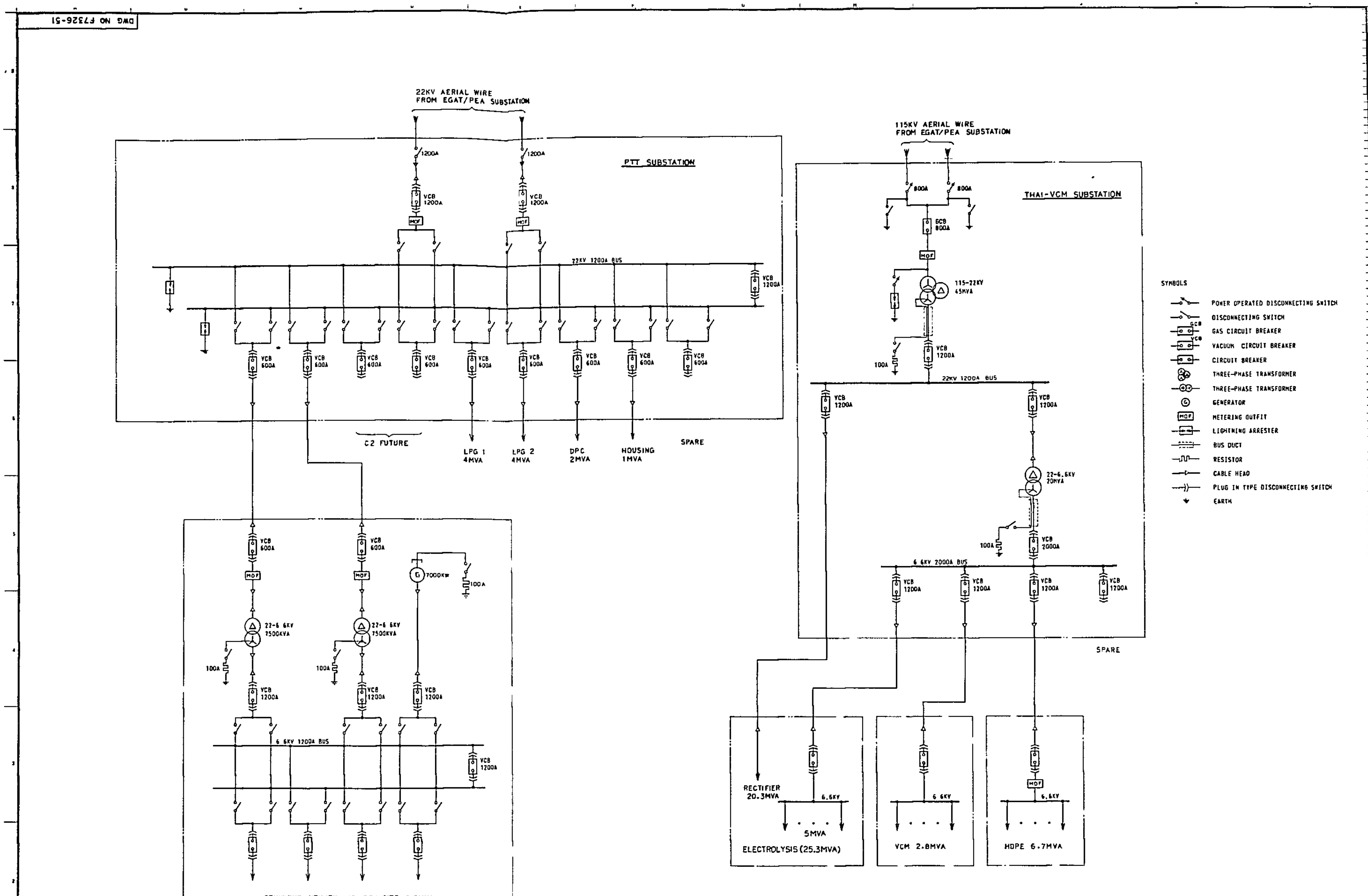
Receiving substation
Power plant
Water-treatment facility
Steam generator
Cooling water facility
Air separation facility
Instrument air facility
Waste water treatment facility

Utility facilities shall be centralized as above to achieve economy and facilitate control of operation. Especially, the power plant and steam generator shall be combined with process plants to ensure the maximum efficiency as a total system and to display flexibility so as to fully cope with sharp variation of load for safe operation.

4–3–1 Receiving Substation

The receiving substation consists of two systems–one for the ethylene plant and the utility center and the other for the electrolysis, VCM, and HDPE plants, as shown by a single line diagram (see Fig. V-12).

1) Since the LDPE plant is under construction at a site 20 km distant, utilities supply integration with this petrochemical complex is unthinkable.



ETHYLENE AND VCM PLANT PROJECT IN THAILAND

SINGLE LINE DIAGRAM

J I C A | FIG. V-12

Power for the ethylene plant and the utility center is to be received at the PTT substations from the EGAT/PEA substation[1] through a 22-kV, 2-feeder system, and delivered to the ethylene plant and the utility center where the voltage is stepped down to 6.6 kV, and connected to the circuit from the gas-turbine generator and supplied to each user.

Power for the electrolysis, VCM, and HDPE plants is delivered through 115-kV, 2-feeder system from the above mentioned EGAT/PEA substation to the substation for the electrolysis and VCM plants to be stepped down to 22 kV and 6.6 kV respectively for supply to each user.

4–3–2 Power Plant

Shutdown of an ethylene plant caused by a power interruption may incur a great loss. In this project, therefore, a gas-turbine generator (output about 7,400 kW) is installed as an independent power plant. The 3,200 kW normal load requirement of the ethylene plant and the utility center is met by this generator. This generator is operated in parallel with the commercial power system so that, should the gas turbine trip, the plants continue operation. Further, an emergency diesel generator is installed so that the plants are safely stopped when supply from both the gas-turbine generator and the commercial power system are stopped.

4–3–3 Water Treatment Facility

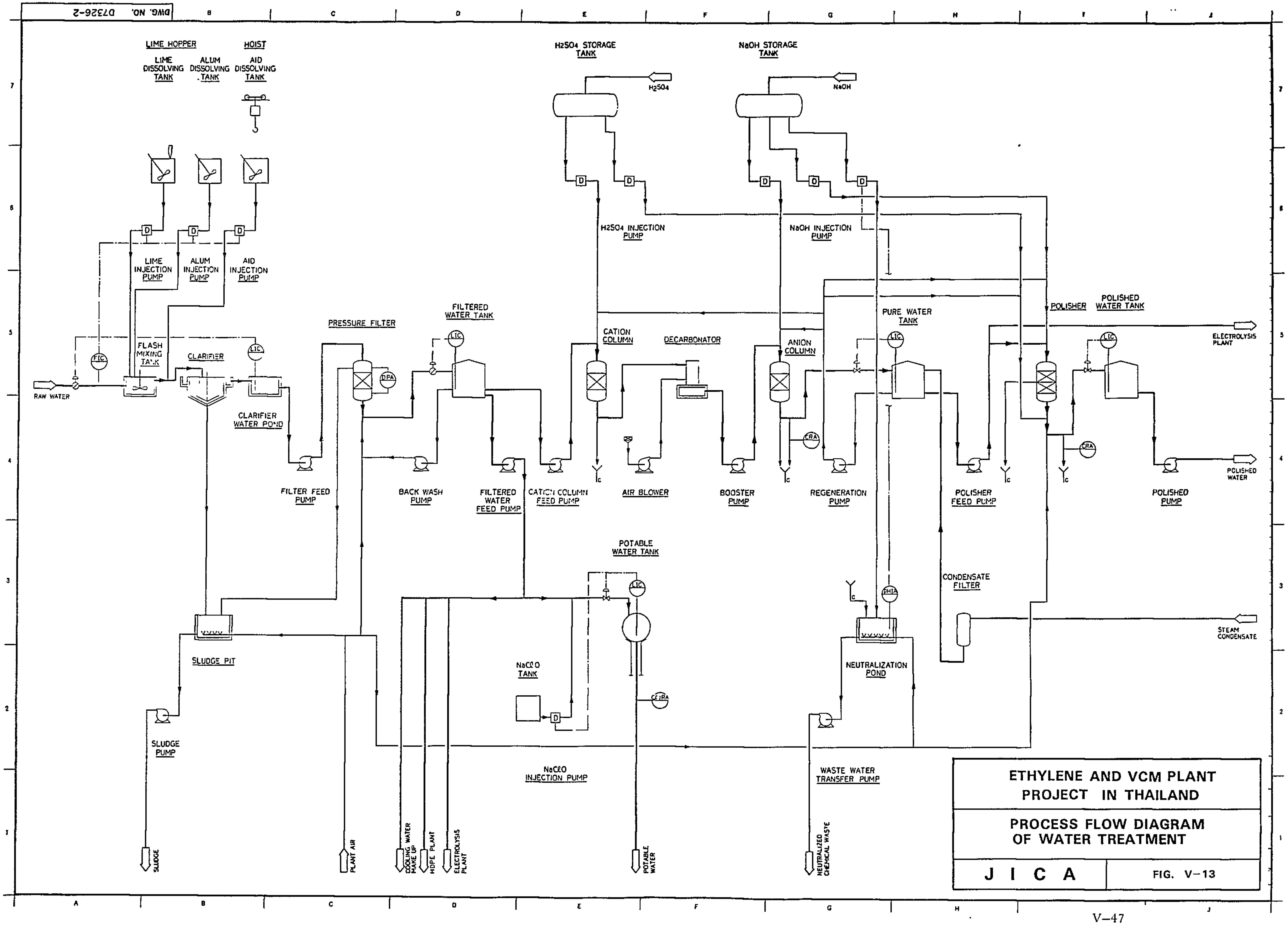
Raw water from the Dok Krai reservoir undergoes treatment in accordance with the flow diagram in Fig. V-13 and is then supplied to each facility. Raw water is firstly passed through a clarifier and a sand filter to reduce turbidity, then, the filtered water being used as cooling water make-up, process water, and potable water. A part of the filtered water is then sent to an ion-exchange demineralizer. The demineralized water is sent through a polisher to a steam generator. A part of filtered water is also delivered to the electrolysis plant.

The steam condensate used in the process plant is also treated at this polisher to be recycled as boiler water.

The capacity of each facility is as shown below:

Clarifier	550 t/h
Sand filter	524 t/h
Potable water facility	10 t/h
Demineralizer	174 t/h
Polisher	186 t/h
Pure water tank	2,700 M^3

1) As previously mentioned. This is called "Rayong-2 substation"


DWG. NO. D7326-2
LIME HOPPER
HOIST
LIME DISSOLVING TANK
ALUM DISSOLVING TANK
AID DISSOLVING TANK
H2SO4 STORAGE TANK
H2SO4
NaOH STORAGE TANK
NaOH
LIME INJECTION PUMP
ALUM INJECTION PUMP
AID INJECTION PUMP
H2SO4 INJECTION PUMP
NaOH INJECTION PUMP
POLISHER
POLISHED WATER TANK
PURE WATER TANK
ELECTROLYSIS PLANT
FILTERED WATER TANK
PRESSURE FILTER
CATION COLUMN
DECARBONATOR
ANION COLUMN
FLASH MIXING TANK
CLARIFIER
RAW WATER
CLARIFIER WATER POND
FILTER FEED PUMP
BACK WASH PUMP
FILTERED WATER FEED PUMP
CATION COLUMN FEED PUMP
AIR BLOWER
BOOSTER PUMP
REGENERATION PUMP
POLISHER FEED PUMP
POLISHED PUMP
POLISHED WATER
POTABLE WATER TANK
CONDENSATE FILTER
STEAM CONDENSATE
SLUDGE PIT
NaClO TANK
NEUTRALIZATION POND
SLUDGE PUMP
NaClO INJECTION PUMP
WASTE WATER TRANSFER PUMP
SLUDGE
PLANT AIR
COOLING WATER MAKE UP
HDPE PLANT
ELECTROLYSIS PLANT
POTABLE WATER
NEUTRALIZED CHEMICAL WASTE
ETHYLENE AND VCM PLANT PROJECT IN THAILAND
PROCESS FLOW DIAGRAM OF WATER TREATMENT
J I C A
FIG. V-13

4–3–4 Steam Generator

Fig. V-14 shows the balance of steam required for this project. Steam is generated by a waste heat boiler of the gas turbine and a package boiler. In order to increase the overall thermal efficiency by recovering as much waste heat of the gas turbine as possible, load is normally applied to the waste heat boiler while the package boiler is operated at the minimum load so that, when the gas turbine trips and steam generation from the waste heat boiler stops, the package boiler immediately takes over the load. The after-burner is required at the waste heat boiler flue to generate the steam of required pressure and temperature.

The feedwater pump and forced draft fan, etc. are driven by the steam turbine so that the package boiler may continue operation in the event of power failure. Pressure-reducing, temperature-reducing devices are provided to supply steam of the required pressure and temperature to each plant.

The capacity of the facility is as follows:

Waste heat boiler	60 t/h x 47 ATG x 445°C
Package boiler	60 t/h x 47 ATG x 445°C
Deaerator	210 t/h x 2 ATG x 133°C
Feedwater pump 2	198 t/h x 57 ATG x 133°C
	1 : Turbine driven
	1 : Motor driven

Pressure-reducing, temperature-reducing devices:

42 ATG x 440°C → 15 ATG x 210°C	40 t/h
15 ATG x 210°C → 2 ATG x 150°C	30 t/h

4–3–5 Cooling Water Facility

A cooling water facility is to be provided separately for use of the ethylene plant and the utility center, and for use of the electrolysis and VCM plants. The cooling water facility consists of a cooling tower, cooling water circulating pump, and chemical feeder.

The facilitie capacity is as follows (from page after next):

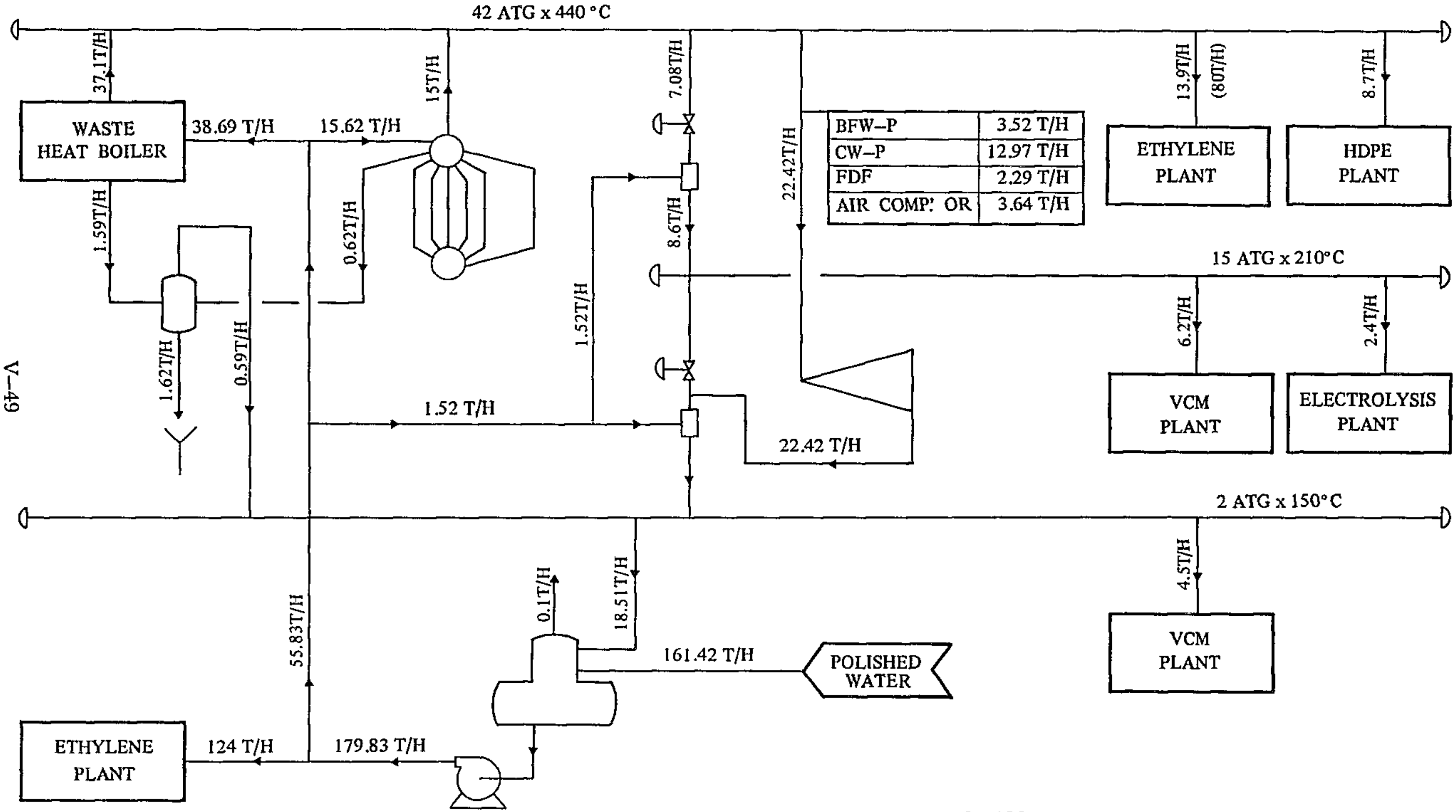


Fig. V–14 STEAM SYSTEM BLOCK FLOW DIAGRAM

Facility for use of the ethylene plant and utility center:

Cooling tower	2,220 t/h x 4 cells	
Circulating pump 2	8,880 t/h x 40m	
		1 : Turbine driven
		1 : Motor driven
Chemical feeder	1 set	

Facility for VCM and Electrolysis plant:

Cooling tower	2,220 t/h x 2 cells	
Circulating pump 2	4,440 t/h x 40m	
		2 : Motor driven
Chemical feeder	1 set	

4–3–6 Air Separation Facility

This facility is to produce oxygen for use of the VCM plant and to produce nitrogen to be used as inert gas for purging. Low temperature air separation is adoped in this device.

The produced oxygen is supplied as gas to the VCM plant while nitrogen gas other than used as inert gas is released to the air.

This facility is also capable of producing liquid nitrogen. A part of produced nitrogen is stored as liquid nitrogen to be used as purge gas in case of emergency.

The facility capacity is as follows:

Oxygen capacity	1,200 Nm^3/hr
Nitrogen capacity	1,300 Nm^3/hr
Liquid nitrogen capacity	60 Nm^3/hr

4–3–7 Instrument Air Facility

This facility is for production of instrument air and plant air to be used in this complex and comprised of air compressors and an air dryer. The air compressed to 7 ATG is sent to an air dryer filled with absorbent to be dried until its dew point becomes −40°C. Then, the dry air is delivered as instrument air. For plant air, the air as compressed is used.

The capacity of the facility is as follows:

Air compressor 2	2,500 Nm^3/h x 7 ATG
	1 : Turbine dirven
	1 : Motor driven
Air dryer 1	2,500 Nm^3/h
Dew point	-40°C at 7 ATG

4–4 OFF-SITE FACILITIES FOR ETHYLENE PLANT

The following off-site facilities are included in this project.

1. Interconnection Facilities

   Telephone intercom, paging, off-site piping, eye washer, shower, etc.

2. Central Laboratory (850 m^2)

   Equipment for testing and analysis of feedstock and products.

3. Maintenance Shop with Warehouse (6,525 m^2)

   Shop equipped for inspection, testing and repair of equipment, rotating machinery, piping, electric systems, etc.

4. Warehouse

   Warehouse for spare parts, chemicals and catalyst storage.

5. Administration Building with First Aid Facilities (625 m^2)

   Expansion of an administration building for the gas processing plant is to be done.

6. Canteen (1,200 m^2)

7. Fire Truck Station (600 m^2)

   Three chemical fire-fighting trucks and one ambulance are provided.

8. Fire-fighting Facility

Hydrants and fire water pipelines, pumps, etc. are provided.

9. Other Buildings

Gate House 81 m^2
Garage 150 m^2

10. Pipeline

Pipeline for conveying ethylene gas to the LDPE plant; Pipe size 6-5/8", pipe length, 27 km

11. Others

Sewers, trenches, ditches, roads, fences, etc. as required at the site.

4–5 VCM PLANT

4–5–1 Introduction

According to the worldwide tendency regarding the vinyl chloride monomer process, an oxygen-based balanced oxychlorination vinyl chloride monomer process has been selected for this feasibility study. An air-based balanced oxychlorination vinyl chloride monomer process, which has become outdated, can not be recommended due to its inferior efficiency of raw material utilization and energy utilization as well as its air pollution problem.

4–5–2 Design Basis

The VCM plant producing 80,000 t/y of vinyl chloride monomer adopts the Mitsui Toatsu balanced oxychlorination vinyl chloride monomer process which is recognized as one of the most advanced and economical processes commercially proven in the world.

(1) Function

The VCM plant shall be designed to produce VCM from ethylene, chlorine and oxygen. The general processing scheme is shown in the attached process flow diagram. The process description is summarized in subsection 4–5–3.

(2) Plant capacity

The VCM plant shall be designed for production of 80,000 of VCM in 8,000 operating hours per calendar year.

(3) Feedstock specifications

The design feedstock shall have the following characteristics:

(a) Gaseous Ethylene

Composition	
Ethylene	99.9 mol% min.
Methane & saturates	0.1 mol% max.
Acetylene	9 mol ppm max.
C_3's & heavier	10 mol ppm max.
CO	5 wt ppm max.
CO_2	5 wt ppm max.
Sulfur as H_2S	1 wt ppm max.
Pressure	16 kg/cm^2G
Temperature	30°C
Phase	Gas

(b) Gaseous Chlorine

Composition	
Cl_2	99.2 mol% min.
O_2	0.5 mol% max.
H_2	0.03 mol% max.
CO_2	0.3 mol% max.
Water	10 wt ppm max.
Pressure	3.0 kg/cm^2G
Temperature	Ambient
Phase	Gas

(cont'd)

(c) Gaseous Oxygen

Composition	
Oxygen	99.5 mol% min.
Pressure	4.0 kg/cm^{2}G
Temperature	Ambient
Phase	Gas

(4) Product specifications

The VCM plant shall be designed to produce the product and by-product specified below when processing the design feedstocks.

(a) VCM

Composition (Dry Base)	
VCM	99.9 wt% min.
Acetylene	5 wt ppm max.
Butadiene	10 wt ppm max.
Chlorinated compounds	200 wt ppm max.
Hydrogen chloride	1 wt ppm max.
Iron	5 wt ppm max.
Water	200 wt ppm max.
Pressure	20 kg/cm^{2}G
Temperature	Ambient
Phase	Liquid

(b) Hydrochloric Acid (Byproduct)

Composition	
HCl	18 wt% aq.
H_2O	Balance
Pressure	3 kg/cm^{2}G
Temperature	45°C max.

Note. Byproduct hydrochloric acid has high quality as a chemical which can be used for the electrolysis plant.

(5) Yield of product

The VCM plant shall be designed to deliver the following estimated yield of products with specifications as per subsection (4) above, when supplied with design feedstocks as specified is subsection (3) above.

Products	kg/hr
Vinyl chloide monomer	10,000
Hydrochloric acid	900

Feedstocks	kg/hr
Ethylene (as 100%)	4,750
Chlorine (as 100%)	6,000
Oxygen (as 100%)	1,500

(6) Utilities specifications

The VCM plant shall be designed to use the following utilities with the characteristics as specified below:

(a) Steam

	Pressure (kg/cm^2 g)	Temperature (°C)
15 K steam	15	210
2 K steam	2	150

(b) Cooling water

	Pressure (kg/cm^2 g)	Temperature (°C)
Cooling water supply	5	32 max.
Cooling water return	2	41 max.

(c) Electricity

	Voltage	Type	Frequency
High voltage line	6,000V	3 phase	50 Hz
Low voltage line	400V	3 phase	50 Hz
Lighting	230V	Single phase	50 Hz

(d) Fuel gas

Fuel gas imported from the battery limits shall be used as fuel gas at the EDC cracker and incinerator, and are specified as follows:

	No. 1 Fuel	No. 2 Fuel
Source	Gas processing plant	Electrolysis plant
Composition	Methane rich gas (Sulfur-free)	Hydrogen gas
LHV	9,400 kcal/Nm^3	3,050 kcal/Nm^3
Pressure	4 kg/cm^2G	3 kg/cm^2G
Temperature	Ambient	Ambient
Flow rate	Balance	160 kg/hr max.

(e) Nitrogen gas

Purity	99.5 mol% min.
Pressure	7 kg/cm^2G
Temperature	Ambient

(f) Instrument air

Characteristics	Oil free/dustless
Dew Point	-40°C at 7 kg/cm^2G
Pressure	7 kg/cm^2G
Temperature	Ambient

(g) Plant air

Characteristics	Oil free
Pressure	7 kg/cm^2G
Temperature	Ambient

(h) Fire-fighting water

Pressure	9 kg/cm^2G
Temperature	Ambient

(i) Drinking water

Pressure	2 kg/cm^2G max.
Temperature	Ambient

(7) Estimated utility consumption

Steam:	15 kg/cm^{2}G 6.2 t/hr		Total: 10.7 t/hr
	2 kg/cm^{2}G 4.5 t/hr		
Cooling water:		2,700 m^3/hr	
Fuel gas:		10.7 MMkcal/hr	
Electric power:		1,200 KWH/hr	

(8) Catalyst and chemicals

The design of the VCM plant shall be based upon the availability of catalysts and chemicals shown below:

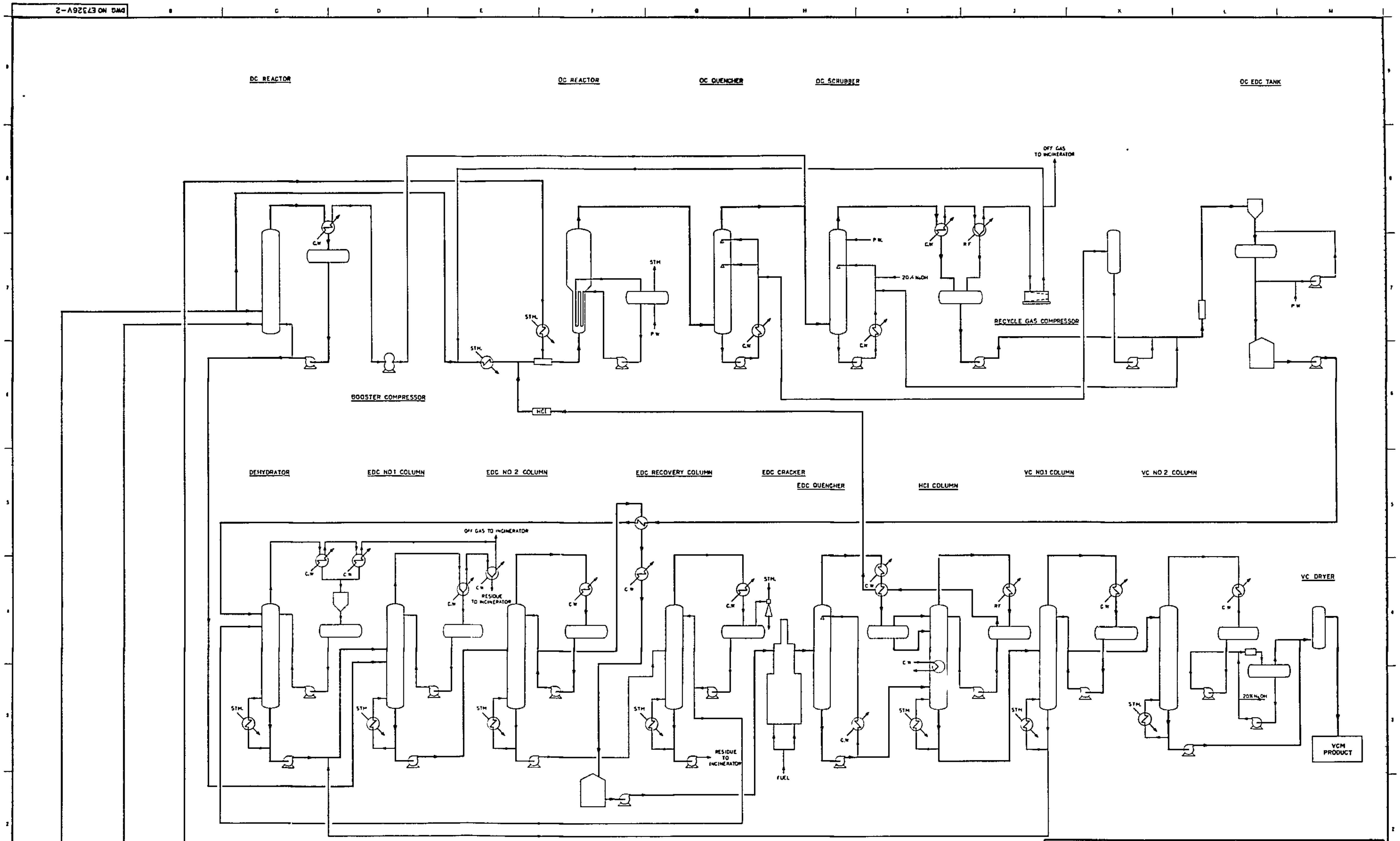
DC catalyst
OC catalyst
Caustic soda solution
Solid caustic soda
Ammonia
Refrigerant (Freon 22)
EDC (for initial start-up)
VCM (for initial start-up)

4–5–3 Process Description

The VCM plant consists of the following sections.

Direct Chlorination Section
Oxychlorination Section
EDC Purification Section
EDC Cracking Section
VCM Purification Section
Waste Matter Treating Section
Utilities Section
HCl Recovery Section
Tank Yard Section

The general processing scheme of VCM production sections is summarized on the process flow diagram attached (see Fig. V-15). The process description of each section is mentioned hereunder;



ETHYLENE AND VCM PLANT PROJECT IN THAILAND

PROCESS FLOW DIAGRAM VCM PLANT

J I C A FIG. V-15

(1) Direct Chlorination (DC) Section

Ethylene reacts with chlorine to form EDC according to the following chemical equation;

$$C_2H_4 + Cl_2 \xrightarrow{\text{solvent}} C_2H_4Cl_2 \text{ (EDC)} + 48 \text{ Kcal}$$

Ethylene and chlorine are fed into a DC reactor where the reaction takes place in the liquid phase of EDC at its boiling point. The heat of reaction is removed by vaporization of EDC.

The reactor overhead is sent to a condenser, where the condensed EDC is partially withdrawn as the product, while the remainder is returned to the reactor to keep its liquid level. The noncondensate is then sent to the Oxychlorination (OC) Section.

(2) Oxychlorination (OC) Section

Ethylene reacts with hydrogen chloride and oxygen to form EDC according to the following chemical equation;

$$C_2H_4 + 2HCl + 1/2\,O_2 \xrightarrow{\text{catalyst}} C_2H_4Cl_2 \text{ (EDC)} + H_2O + 63 \text{ Kcal}$$

The reaction takes place on micro-spherical catalyst of Cu-Al compounds specially provided for this purpose. The oxychlorination reaction is carried out in a fluidized bed reactor.

The fresh feed raw materials of ethylene, hydrogen chloride and oxygen with almost stoichiometric quantities are fed to an OC reactor after mixed with the recycle gas. Ethylene is oxychlorinated to EDC on the fluidized catalyst.

The heat of reaction is removed effectively by circulating hot water through cooling tube coils in the reactor and recovered as steam which is consumed economically in the EDC Purification Section.

The reaction mixture from the reactor is quenched and scrubbed successively in an OC Quencher and in a caustic scrubber. The caustic scrubber overhead is effectively cooled down by condensers to the allowable minimum temperature to separate out the produced EDC in the reactor from the recycle gas. The noncondensate gas from the condenser is recycled back to the reactor after purging a small quantity of its equivalent to inert gases contained in the raw materials.

The purge gas is sent to the HCl Recovery Section to be burned out and hydrochloric acid is recovered and utilized in the electrolysis plant. Thus the process is an air-pollution-free process.

The quenched EDC from the quencher is neutralized by the spent caustic solution from the caustic scrubber and is sent to a decanter together with the condensed EDC from the condensers. The separated EDC is the product of this section. The water layer from the decanter is sent to the HCl Recovery Section after treated in the Waste Matter Treating Section.

(3) EDC Purification Section

The EDC from DC Section and OC Section and the recovered EDC from the VCM Purification Section are purified to meet the specifications of EDC to be fed to EDC crackers.

The wet EDC from the OC Section is dehydrated in a dehydrator and then combined with the recovered EDC and the dry EDC from the DC Section to be rectified in the succeeding distillation columns to remove low and high boiling impurities.

The byproducts (chloric residues) generated are sent to the HCl Recovery Section.

(4) EDC Cracking Section

EDC is thermally decomposed to VCM and HCl according to the following equation:

$$C_2H_4Cl_2 \xrightarrow{\text{heat}} C_2H_3Cl\ (\text{VCM}) + HCl - 19\ \text{Kcal}$$

The reaction is carried out without catalyst while passing through EDC cracking tube coil under moderately high operation pressure.

The purified EDC is pumped up by EDC cracker feed pumps to EDC cracker. Cracking of EDC to VCM is carried out at high temperature and high pressure, here.

The heat of vaporization, superheating and cracking of EDC is provided by the elaborately controlled firing operation to suppress formation of byproducts and cokes. The hot effluent gas from the EDC cracker is quenched in an EDC quencher and then sent to the VCM Purification Section.

(5) VCM Purification Section

Gas and liquid streams from EDC quencher fed to a HCl column where HCl is separated and rectified to be delivered as the very pure hydrogen chloride gas to OC Section. The bottoms of the column is sent to a VC No. 1 column where VCM is separated from the uncracked which is recycled back to the EDC Purification Section. The distillate of the column is treated in the succeeding VCM finishing facilities to obtain VCM with polymerization grade quality.

(6) Waste Matter Treatment Section

In this section, the off-gases and waste water from each section of the plant are pretreated for further processing.

The off-gases containing a small amount of harmful gases such as hydrogen chloride are scrubbed in an off gas scrubber using spent caustic solution from the OC Section before sent to the HCl Recovery Section.

The small amount of EDC contained in the process effluent water is stripped off in an EDC stripper to recover EDC before sent to the HCl Recovery Section.

(7) Utilities Section

A part of steam condensate of the VCM plant is utilized as the coolant of the OC Reactor and as process water within the battery limits. The remainder is exported to the battery limits. The generated steam from the OC Section is combined effectively in this section to be used in EDC Purification Section.

A refrigeration unit is provided to supply refrigerant (Freon 22) for corresponding condensers of the VCM plant.

(8) HCl Recovery Section

In this section, light and heavy ends from EDC Purification Section and the normal off-gases from the VCM plant are burnt in an incinerator to recover HCl as a valuable byproduct.

The high temperature combustion gas from the incinerator is quenched and sent to an absorber to recover HCl as hydrochloric acid (18% wt aq.). Off gas from the absorber is then scrubbed by the spent caustic solution from the waste matter treatment section for safe disposal.

The waste water from this section is finally sent to the waste water treatment facilities in the utility center after being neutralized by hydrochloric acid.

(9) Tank Yard Section

In this section, two product VCM tanks and two EDC tanks are provided.

The product VCM tanks, two spherical tanks with a storage capacity of one day's production each, are provided. The product VCM of the specified quality is sent to one of the tanks continuously from the VCM Purification Section, while the stored VCM in the other tank is delivered to another storage tank which is to be located at the VCM shipping area near to a jetty facilities for the shipment of VCM to PVC manufacturing company.

The EDC storage tanks are provided to store crude EDC form the DC Section since the DC Section is to be operated as well as the electrolysis plant during the annual turn-around period of the ethylene plant.

4–6 SALT ELECTROLYSIS PLANT

4–6–1 General Description

This feasibility study is carried out on the assumption that the ion exchange membrane process is adoped, in accordance with the most advanced technology for salt electrolysis.

In addition to this method, the mercury process and asbestos diaphragm process have long been used for salt electrolysis. A brief comparison between them is described later.

4–6–2 Design Base

Design of the salt electrolysis plant based on the ion exchange membrane process is made on the assumption of adopting Asahi Glass Process; this is amply justified by the advanced technology and abundant industrial records of use of this process.

The design base is as shown below:

(1) Production quantities

NaOH : 53,500 t/y (100%)
For sale : 51,600 t/y
For home consumption : 1,900 t/y

Cl_2 : 48,000 t/y (100%)
To be delivered to VCM Plant

H_2 : 1,820 Nm^3/h (100%)
To be delivered to VCM Plant

(Facility capacity of Cl_2 : 49,200 t/y)

(2) Product quality

Caustic soda

NaOH	: 50±1%
NaCl	: 30 wt.ppm
Pressure	: Atmosphere
Temperature	: 50°C or below
Phase	: Liquid

Chlorine gas

Cl_2	: 99.0 vol% or more
O_2	: 0.5 vol%
H_2	: 0.03 vol%
CO_2	: 0.3 vol%
Pressure	: 3.0 kg/cm^2 g
Temperature	: 20°C
Phase	: Vapor

Hydrogen gas

H_2	: 99.9 vol% or more
O_2	: 0.03 vol% or less
Pressure	: 3.0 kg/cm^2 g
Temperature	: 42°C
Phase	: Vapor

(3) Raw material quality

Salt

NaCl	: 84%
SO_3	: 0.31%
MgO	: 0.4%
CaO	: 0.2%
Insoluble Matter	: 0.5%
H_2O	: 14.59%

Sulfuric acid

H_2SO_4	: 98%

(4) Major unit consumption rates

Major unit consumption rates for the salt electrolysis plant are as follows.

(a) Major unit consumption rates

	Per ton of NaOH produced	Per ton of Cl_2 for VCM
Salt (84% purity)	1.70 t/T	1.90 t/T
Electric Power for Electrolysis	2.300 AC KWH/T	2,642 AC KWH/T (with rectification factor assumed to be 97%)
General Electric Power Salt solution, electrolysis and concentration	31 AC KWH/T	34.5 AC KWH/T
Others	182.6 AC KWH/T	203.5 AC KWH/T
Steam	0.40 t/T (on the assumption that all product for sale is concentrated)	

Others : Expenses for electrodes and ion exchange membrane : ¥263,000,000/y

(b) Cost of other materials for purification

	Per ton of NaOH produced	Per ton of Cl_2 to VCM plant
Salt Solution, Electrolysis and Concentration	382.2 Baht/t	425.9 Baht/t
Others	70.6 Baht/t	78.7 Baht/t

Unit consumption rate of NaOH for home consumption:
36.1 kg/unit ton of NaOH produced
(40.2 kg/unit ton of $C\ell_2$ for VCM)

(c) Unit consumption rates of other utilities

	Per ton of NaOH produced	Per ton of $C\ell_2$ to VCM plant
Industrial Water	2.10 t/T	2.34 t/T
Cooling Water	138.1 t/T	153.9 t/T
N_2	1.55 Nm^3/T	1.73 Nm^3/T
Demineralized Water	1.52 t/T	1.70 t/T
Instrument Air	88.2 Nm^3/T	98.3 Nm^3/T
Plant Air	3.4 Nm^3/T	3.8 Nm^3/T

4–6–3 Explanation of Process

(1) Outline of process

(a) Comparison of various NaOH production processes

Three distinct industrial production processes for NaOH are available – mercury process, asbestos diaphragm process, and ion exchange membrane process.

A brief description is given below of the differences between these three processes with importance attached to the flow of material in particular.

Mercury Process :

Fig. V-16 illustrates the flow of materials in the mercury process. It is known from Fig. V-16 that, in the mercury process, brine and mercury circulate through the system while only a 50% NaOH aqueous solution leaves the system as a matter of principle.

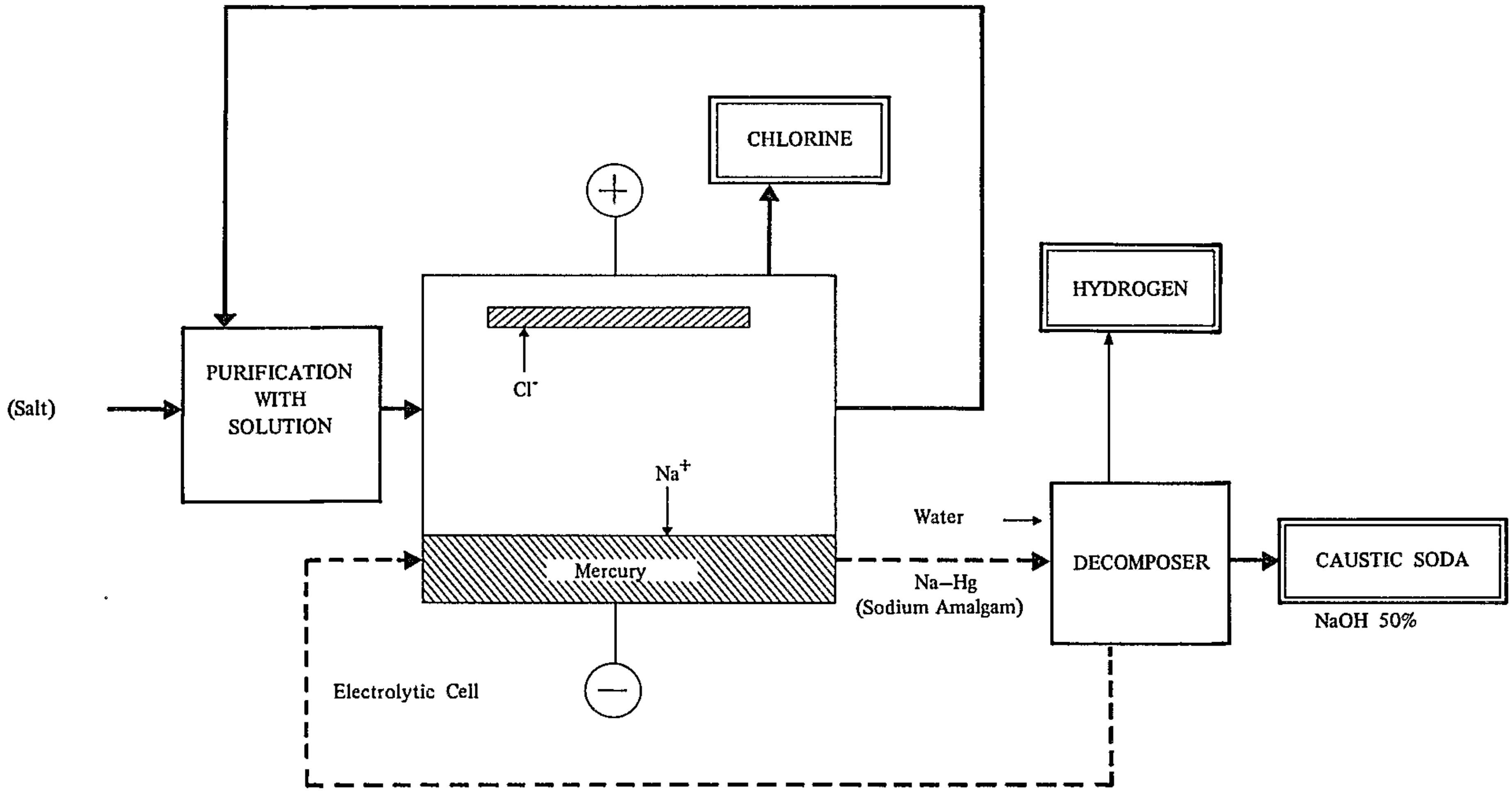


Fig. V–16 MERCURY PROCESS

This process has the potential problem of mercury leakage which was attributed to the following four points :

1. Mercury in effluent
   (leakage of water and salt water in contact with mercury)

2. Mercury in sludge
   (brine mud, anode plate, granular decomposition product)

3. Mercury in products
   (in chlorine gas, hydrogen gas and caustic soda)

4. Leakage during process
   (evaporation in the air)

An adequate measure has been taken for each of the above causes by establishing a closed system.

<u>Asbestos Diaphragm Process :</u>

Fig. V-17 illustrates the flow of materials in the asbestos diaphragm process.

It is known from Fig. V-17 that no solution circulates in the asbestos diaphragm process, while saturated brine and a solution consisting of 11 ~ 12% NaOH + 15 ~ 18% NaCl enters and leaves the system respectively.

To obtain product from catholyte, a process of removing salt is required. Usually, this is achieved by means of a multiple effect evaporator.

The multiple effect evaporator permits caustic soda to be concentrated to 49% with elimination of salt. However, approximately 1.1% of salt still remains in the caustic soda. When caustic soda of high grade is required, therefore, it must be further purified.

This is one of major problems encountered in the asbestos diaphragm process.

Further, energy for concentrating caustic soda from 11% to 49% is also required.

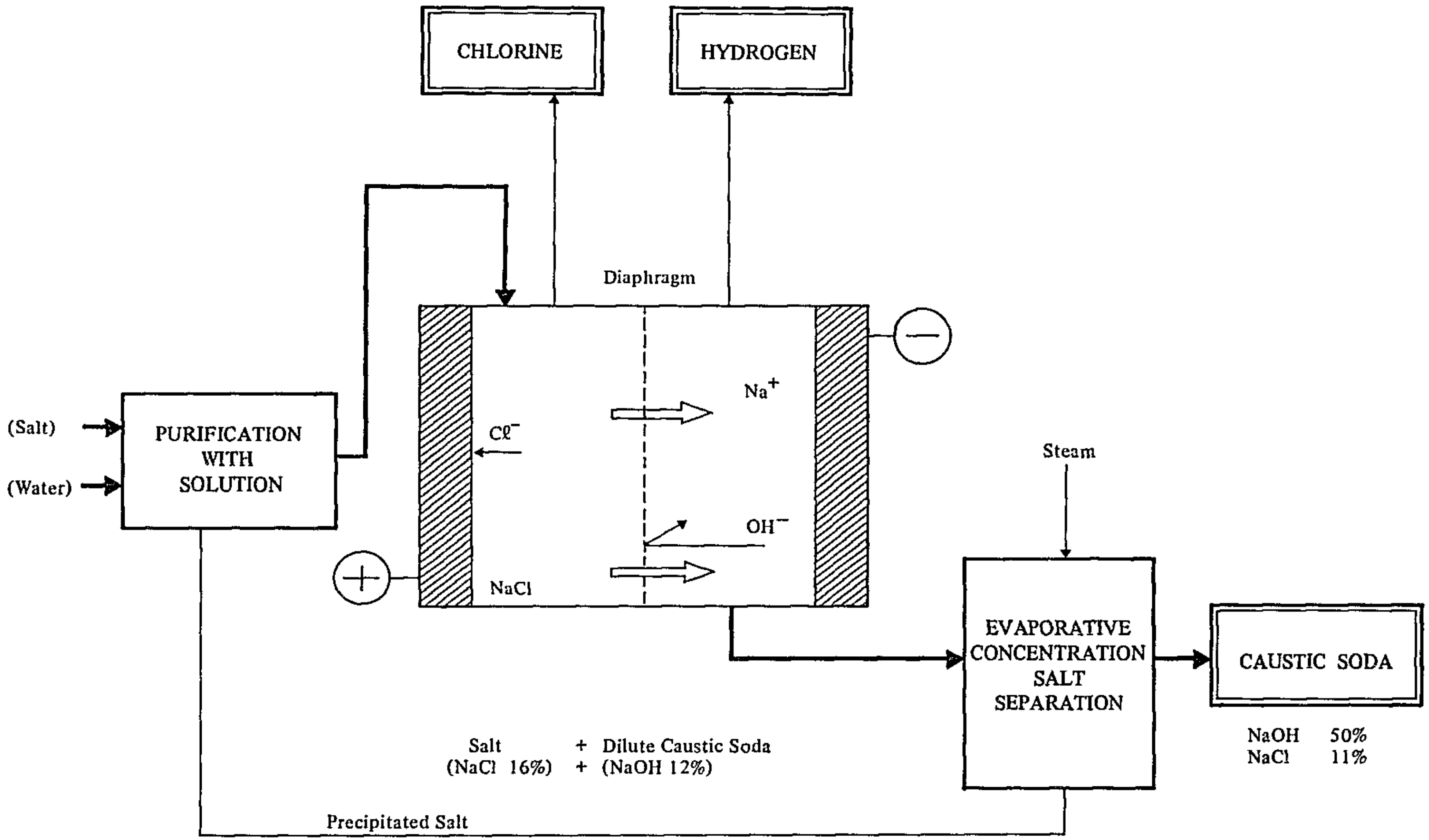


Fig. V–17 ASBESTOS DIAPHRAGM PROCESS

Ion Exchange Membrane Process :

Fig. V-18 illustrates the flow of materials in the ion exchange membrane process.

It is known from Fig. V-18 that, in the ion exchange membrane process, brine circulates through the system while only a 20 ~ 40% NaOH aqueous solution leaves the system as in the case of the mercury process.

This process yields caustic soda of high concentration containing less impurities; thus, the product from the electrolytic cell as it is can be used without further treatment.

When 50% of NaOH is required, concentration is accomplished by a multiple effect evaporator. Since the product obtained from this process contains less impurities such as salt, it needs only a simple facility for concentration.

Further, this process may claim advantages in that the cost of concentration is low because of low steam consumption and that this process incurs no risk of pollution since neither mercury nor asbestos is used.

(b) Features of the ion exchange membrane process

Pollution-free process :

Neither mercury (as used in the mercury process) nor asbestos (as used in the asbestos diaphragm process) is used in this process.

Energy-saving process :

Given below is a comparison between the ion exchange membrane process (Asahi Glass Flemion Process as an example) and other types of process :

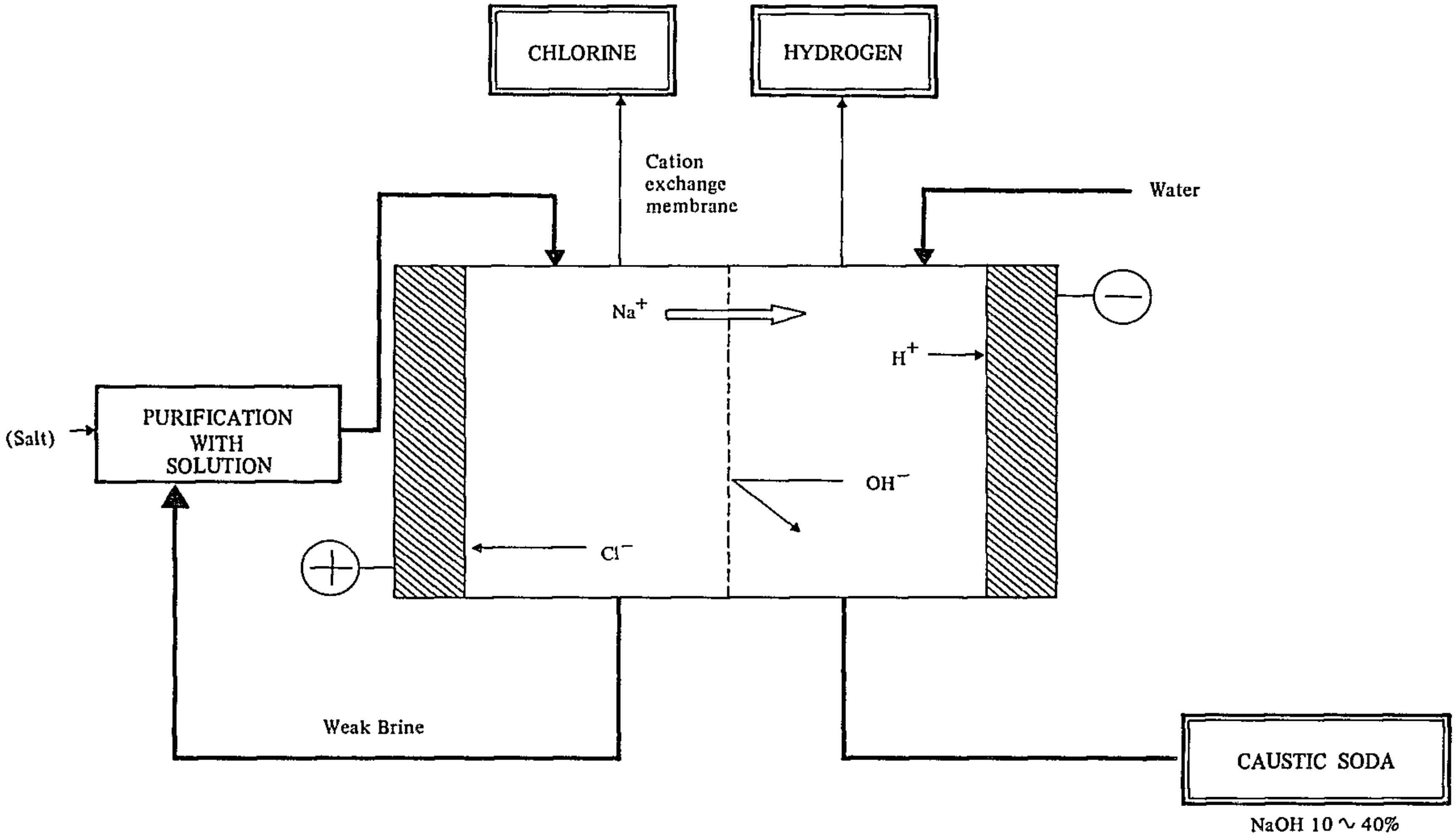


Fig. V—18 ION EXCHANGE MEMBRANE PROCESS

	Asahi Glass Flemion Process	Mercury Process	Asbestos Diaphragm Process
Power Consumption for Electrolysis[4)] (KWH/t)[1)]	(2,300 DC) 2,371 (AC)	(3,200 DC) 3,299 (AC)	(2,580 DC) 2,660 (AC)
Steam (t/t)[2)] (KWH/t)[1)]	(0.42) 84	(0) 0	(2.5) 500
Power Consumption for General Use[3)] (KWH/t)[1)]	50	80	-210
Total (KWH/t)[1)]	2,505	3,379	3,370

Notes : 1) Per ton of caustic soda produced.

2) On the basis of conversion rate as follows :
1t of steam = 200 KWH

3) Power consumption for the salt dissolving, electrolysis, concentration, and $C\ell_2$ (H_2) pressurizing sections.

4) Assuming that rectification efficiency = 97%

High-quality Process :

Caustic soda of equal quality with that of the mercury process is obtainable.

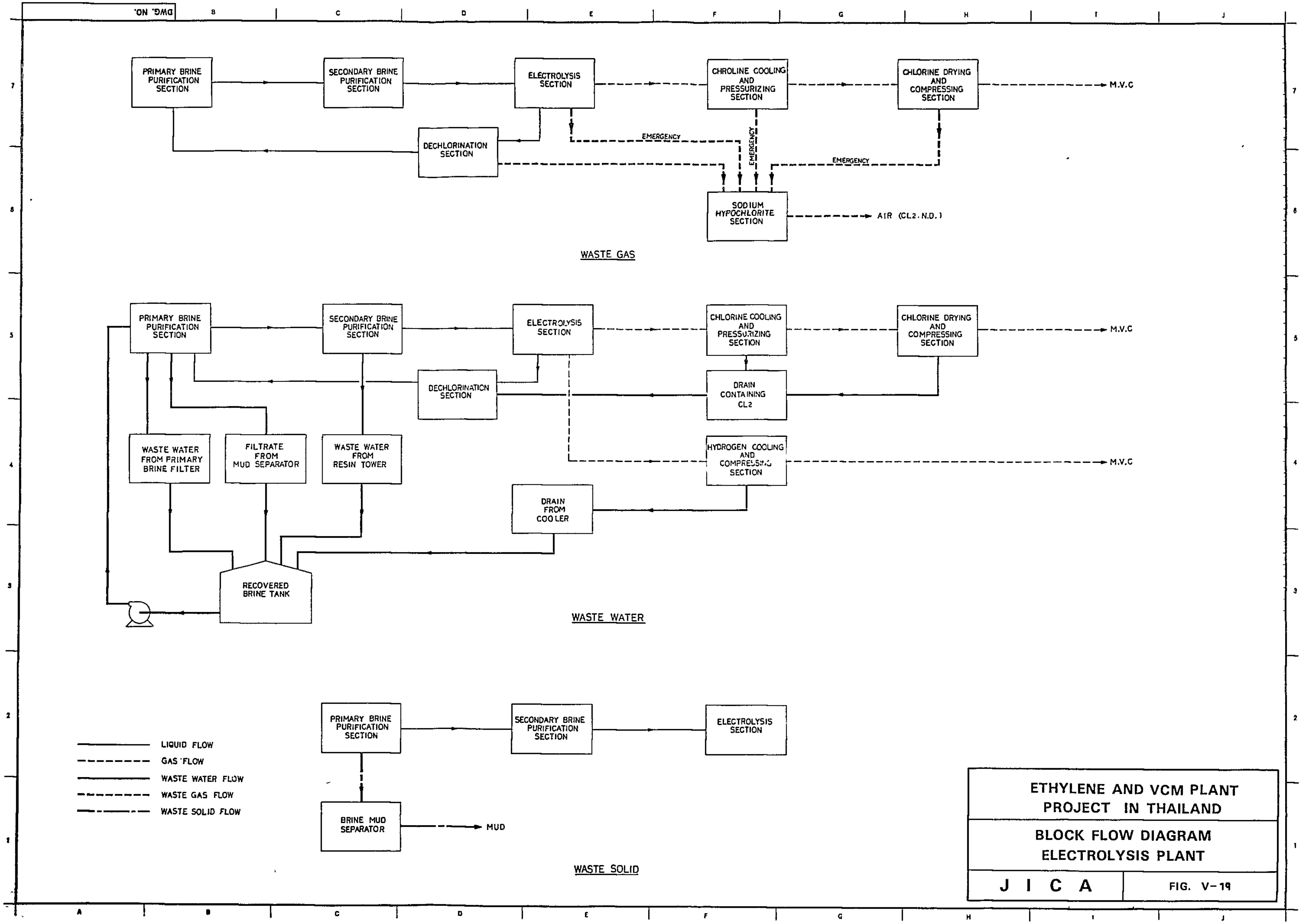
In view of the result of the above comparison, the ion exchange membrane process is to be adopted in this electrolysis plant.

The following description on this process is based on Asahi Glass Flemion Process.

(2) Outline of the process (see Figs. V-19 and V-20)

(a) Salt dissolving and primary brine purification section

Sodium chloride, which is to be electrolyzed, is dissolved in weak brine circulating in the system to be fed to an electrolytic cell.


DWG. NO.
PRIMARY BRINE PURIFICATION SECTION
SECONDARY BRINE PURIFICATION SECTION
ELECTROLYSIS SECTION
CHROLINE COOLING AND PRESSURIZING SECTION
CHLORINE DRYING AND COMPRESSING SECTION
M.V.C
DECHLORINATION SECTION
EMERGENCY
EMERGENCY
EMERGENCY
SODIUM HYPOCHLORITE SECTION
AIR (CL2. N.D.)
WASTE GAS
PRIMARY BRINE PURIFICATION SECTION
SECONDARY BRINE PURIFICATION SECTION
ELECTROLYSIS SECTION
CHLORINE COOLING AND PRESSURIZING SECTION
CHLORINE DRYING AND COMPRESSING SECTION
M.V.C
DECHLORINATION SECTION
DRAIN CONTAINING CL2
HYDROGEN COOLING AND COMPRESSING SECTION
M.V.C
WASTE WATER FROM PRIMARY BRINE FILTER
FILTRATE FROM MUD SEPARATOR
WASTE WATER FROM RESIN TOWER
DRAIN FROM COOLER
RECOVERED BRINE TANK
WASTE WATER
PRIMARY BRINE PURIFICATION SECTION
SECONDARY BRINE PURIFICATION SECTION
ELECTROLYSIS SECTION
BRINE MUD SEPARATOR
MUD
WASTE SOLID
LIQUID FLOW
GAS FLOW
WASTE WATER FLOW
WASTE GAS FLOW
WASTE SOLID FLOW
ETHYLENE AND VCM PLANT PROJECT IN THAILAND
BLOCK FLOW DIAGRAM ELECTROLYSIS PLANT
J I C A
FIG. V-19

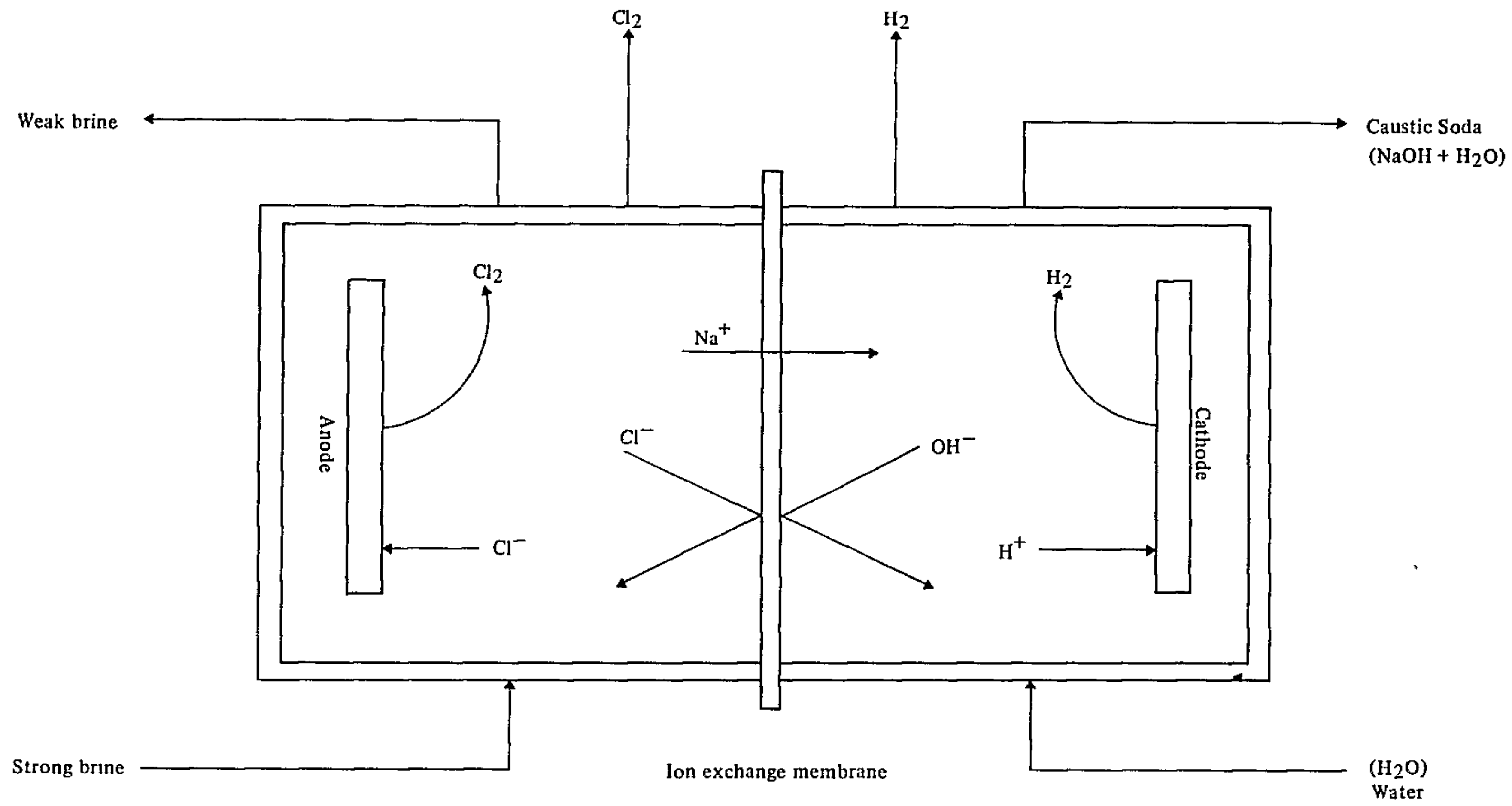


Fig. V—20 PRINCIPLE OF THE ION EXCHANGE MEMBRANE PROCESS

Since it contains hypochlorite (ClO^-), the weak brine from the electrolytic cell is dechlorinated in a dechlorination tower to be sent to a dissolver in which the brine is resaturated with salt.

Since it contains impurities coming from raw salt, the brine from the dissolver is combined with chemicals so that the impurities are made to settle to be separated as brine mud.

The brine is further filtrated for separation of suspended solid to become primary purification brine.

The brine mud is sent to a filter press, in which solid and liquid are separated and the filtrate is recovered as brine.

The series of flows above are automatically controlled to ensure stabilized operation.

(b) Secondary brine purification section

The brine subjected to primary brine purification section contains impurities such as cation though they are very small in quantity.

For the purpose of further purifying the brine obtained from the primary brine purification section to ensure stabilized operation of the electrolytic cell provided with ion exchange membrane continuously for an extended period, a secondary brine purification provided with ion exchange resin is installed.

Switching of backwash, etc. is fully automated; thus, operations to be performed by man are monitoring operations only.

(c) Electrolysis unit (Asahi Glass Flemion Process)

Principle of ion exchange membrane process

Fig. V-20 briefly illustrates the principle of the ion exchange membrane process.

Strong brine enters the anode chamber while Na^+ ions freely penetrate through the cation exchange membrane into the cathode chamber. Cl^- ions discharge electricity at the anode to become chlorine gas. The Cl^- ions, which cannot penetrate through the cation exchange membrane because of being negative, do not move from the anode chamber to the cathode chamber.

In the cathode chamber, on the other hand, the Na^+ ions (which have penetrated through the cation exchange membrane) react with H_2O poured in the cathode chamber to produce NaOH and H^+ ions. Although the OH^- ions move toward the anode chamber, these ions cannot penetrate the cation exchange membrane as they are negative ions. The H^+ ions discharge at the cathode to become hydrogen gas.

It may safely be said that the performance of this ion exchange membrane process is determined by the performance of an ion exchange membrane required to function under severe conditions, that is, both sides are exposed to Cl_2 gas and strong NaOH respectively.

Electrolysis process

As previously described, the ion exchange membrane process proves to be an energy-conserving process, since it is lower in the energy cost compared with other types of process. Since its purity is more than 99%, the Cl_2 gas from this process is sent, through the drying and pressurizing sections, directly to the VCM plant.

The electrolytic cell, which is of single-electrode cell structure and is made of corrosion-resistant material, has features of ease of assembly/disassembly, less loss at shut-down, and compactness which requires only about a half of the floor area necessary for the mercury process.

In the ion exchange membrane process, the ion exchange membrane is the heart of the process. The "Flemion" membrane manufactured by an integrated operation at Asahi Glass Co., Ltd. features a current efficiency as high as 94% ~ 95% owing to its high exchange capacity. This process yields caustic soda of as high concentration as 35 ~ 36wt % at the outlet of the electrolytic cell. Further, concentration can be effected up to 50% with a small consumption of steam.

(d) H_2 cooling, and pressurizing section

The hydrogen gas produced from the electrolytic cell is saturated with moisture at 90°C.

After cooled at a heat exchanger, the hydrogen gas is pressurized by compressor to become a source of clean energy to be used as fuel for the EDC thermal cracking furnace in the VCM plant.

This facility is provided with adequate air-tightness and safety devices in anticipation of an emergency.

(e) Cl_2 gas drying, and pressurizing section

The chlorine gas produced in the electrolytic cell, which is saturated with moisture, is cooled and delivered to the drying process.

In the drying process, the chlorine gas is dehydrated through gas-liquid contact with concentrated sulfuric acid, resulting in approx. 50 ppm water content.

Then, the chlorine gas is pressurized to be sent to the VCM plant.

To prevent the machines from being damaged by change of pressure or surging in the electrolysis system and compressor system, automatic control devices including pressure controls are provided; thus, stabilized operation is ensured. Further, to prevent Cl_2 gas from being released to the air in case of emergency, this process is connected to a chlorine-hazard prevention system, proving to be a pollution-free process.

(f) Caustic soda concentration section

Caustic soda obtained through electrolysis section has a 35 ~ 36% concentration. The product is concentrated to 50%, except for the product for captive use. From the standpoint of energy conservation, the concentration can be done by triple-effect evaporators of counterflow type with heat recovery in the preheater.

Caustic soda delivered from the electrolysis section is concentrated to about 40%, 44%, and to 50% at a first-stage evaporator, second-stage evaporator, and third-stage evaporator respectively.

After delivered to the shipping storage tank, liquid caustic soda is automatically measured to be shipped by lorry.

(g) Chlorine-hazard prevention section

In case of emergency and start-up, Cl_2 gas is absorbed in a chlorine-hazard prevention facility. During ordinary operation, chlorine gas from the dechlorination tower is absorbed in the above facility. Thus, this facility is designed to have a capacity large enough to absorb the whole amount of chlorine gas in case of emergency and start-up.

The 35% caustic soda solution produced from the electrolytic cell is used as absorbent.

In this process, sodium hypochlorite is continuously produced under counter-flow system in which waste gas flows from No. 1 tower to No. 2 tower while caustic soda solution flows countercurrently from No. 2 tower to No. 1 tower.

(h) Utilities within the electrolysis plant

Chilled water facilities

Chilled water is used for chlorine drying and pressurizing sections, and in the dechlorination section. Water at 5°C is obtained from refrigerating machine which uses freon gas as the refrigernat.

Effluent treatment facilities

The electrolysis process is designed to be a closed system from which almost no effluent other than pump seal water, effluent from laboratory analysys, and rainwater exits. Hence there will be no problems regarding suspended solids, BOD or COD; the pH of this effluent will be controlled before it.

In each section, runoff (from rain) will be kept separate from runoff in areas outside the plant in order to minimize effluent quantity.

Others

Other utilities are to be supplied from the utilities center.

4–7 UTILITY AND OFF-SITE FACILITIES FOR VCM AND ELECTROLYSIS PLANTS

The following are included in this project.

1. Main Substation (1,232m^2)
   Details are given in Section 3 – 2 and 4 – 3, of this Chapter.

2. Cooling Water Facilities
   Capacity of the facilities which are to serve the two plants is to be 4,440 t/hr.

3. Interconnection Facilities
   Telephone intercom, paging, offsite piping etc. for the project.

4. Central Laboratory (280m²)
   All equipment needed for testing and inspection of raw materials and products.

5. Maintenance Shop (5100m², incl. warehouse)
   Equipped to be able to repair and maintain process equipment, rotating machinery, piping, electrical systems and instruments.

6. Warehouse
   Spare parts, chemicals and catalyst storage.

7. Administration Building (625m²)
   For use by the Thai-VCM Co. and to include first aid facilities.

8. Canteen (1,000m²)
   Employee use.

9. Fire Truck Station (300m²)
   Including one truck and one ambulance.

10. Fire Fighting Facility
    Fire water mains, hydrants, pumps, etc.

11. Other buildings
    Gate House (81m²)
    Garage (150m²)

12. VCM Pipeline and Shipping Terminal
    Diameter of pipeline for the transport of VCM to the jetty is 3". Pipeline length, 27 km. Shipping terminal near the jetty includes a storage tank.

13. Others
    Sewers, trenches, pitch, roads, fenches for the site.

4–8 HOUSING AND WELFARE FACILITIES

4–8–1 General

Housing is planned to be adequate for the number of persons necessary for operation, maintenance and management of each plant. In accordance with the organization chart given in Chapter 5, the number of persons are as follows.

Ethylene plant (PTT)	344 persons
VCM and electrolysis plants (Thai VCM Co.)	294 persons

4–8–2 Housing Plan

All of the supervisors and staff, as well as shift operators, are to be provided with housing or single men's dormitories. Day workers, office workers and secretaries are expected to commute from their own homes. The housing plan is as follows.

	PTT	Thai VCM Co.
Grade A (Plant manager, department managers)	5 units	5 units
Grade B (Section chiefs)	12 units	12 units
Grade C (Supervisors, staff, engineers)	108 units	73 units
Grade D (Operators)	48 units	27 persons
Single men's housing	48 persons	27 persons
Total	221 persons	144 persons

4–8–3 Housing

Area per Unit (m^2)		PTT		Thai VCM Co.	
		Units(persons)	Area(m^2)	Units(persons)	Area(m^2)
A	185	5	925	5	925
B	140	12	1,680	12	1,680
C	110	108	11,880	73	8,030
D	92	48	4,416	27	2,484
Single men's dorm	20	48	960	27	540
Total		221	19,816	144	13,659

The area given above for the dormitories includes the kitchen, dining, laundry, reception and other common-use facilities.

4–8–4 Other Facilities

Supermarket for common use of people in the housing	500 m^2
Football yard	One
Roads and fences	As needed
Utilities	As needed

4–8–5 Housing Site

Housing for ethylene plant employees and VCM/electrolysis plants employees is to be constructed on separate and adjacent area south of the VCM/electrolysis plants.

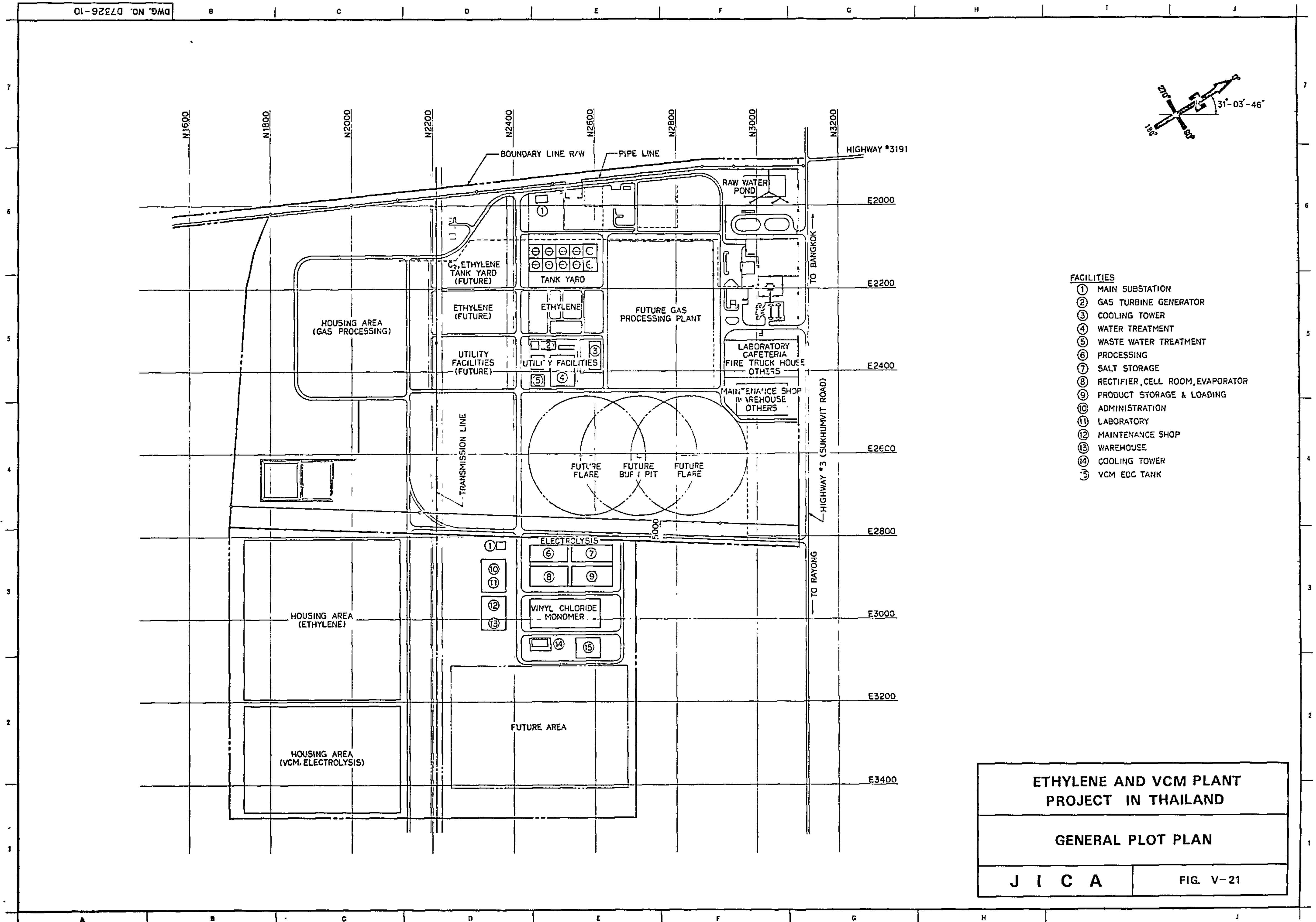
4–8–6 Required Gross Area for Housing Construction

The approximate gross area requirements are as follows.

PTT employees housing	about 146,000 m^2
Thai VCM Co. employees housing	about 100,000 m^2
TOTAL	246,000 m^2
	(60.8 acres)

4–9 PLOT PLAN

The general plot plan for the complex is as shown in Fig. V-21.


DWG. NO. D7326-10
HIGHWAY #3191
BOUNDARY LINE R/W
PIPE LINE
RAW WATER POND
TO BANGKOK
TO RAYONG
HIGHWAY #3 (SUKHUMVIT ROAD)
C2 ETHYLENE TANK YARD (FUTURE)
TANK YARD
ETHYLENE (FUTURE)
ETHYLENE
FUTURE GAS PROCESSING PLANT
HOUSING AREA (GAS PROCESSING)
UTILITY FACILITIES (FUTURE)
UTILITY FACILITIES
LABORATORY CAFETERIA FIRE TRUCK HOUSE OTHERS
MAINTENANCE SHOP WAREHOUSE OTHERS
TRANSMISSION LINE
FUTURE FLARE
FUTURE BURN PIT
FUTURE FLARE
ELECTROLYSIS
VINYL CHLORIDE MONOMER
HOUSING AREA (ETHYLENE)
HOUSING AREA (VCM, ELECTROLYSIS)
FUTURE AREA
N1600
N1800
N2000
N2200
N2400
N2600
N2800
N3000
N3200
E2000
E2200
E2400
E2600
E2800
E3000
E3200
E3400
31°-03'-46"
FACILITIES
① MAIN SUBSTATION
② GAS TURBINE GENERATOR
③ COOLING TOWER
④ WATER TREATMENT
⑤ WASTE WATER TREATMENT
⑥ PROCESSING
⑦ SALT STORAGE
⑧ RECTIFIER, CELL ROOM, EVAPORATOR
⑨ PRODUCT STORAGE & LOADING
⑩ ADMINISTRATION
⑪ LABORATORY
⑫ MAINTENANCE SHOP
⑬ WAREHOUSE
⑭ COOLING TOWER
⑮ VCM EDC TANK
ETHYLENE AND VCM PLANT PROJECT IN THAILAND
GENERAL PLOT PLAN
J I C A
FIG. V-21

CHAPTER 5 PROJECT IMPLEMENTATION AND PLANT OPERATION

5–1 ORGANIZATION FOR IMPLEMENTATION OF THE PROJECT

It is expected that this project will be implemented, in coordination, by two distinct entities. Therefore, two separate organizations will be needed. That is, one organization established by PTT will construct and operate the ethylene plant and utility center, and the other organization will be established by PTT or joint venture with a private sector partner, provisionally called the Thai VCM Co. here, will construct and operate the VCM and electrolysis plants.

Regarding the ethylene plant and utilities center, an organization has already been formed within the PTT head office and is studying major aspects of the project related to the natural gas pipleline, dew point control unit and gas processing plant. It is expected that this organization will be expanded so as to include project site organization, and the study team believes that no major organizational problems will arise as PTT moves into the implementation phase of the project.

In order for the owner to carry out construction and operation of a large plant such as the ethylene plant contemplated for this project, a large number of qualified managers, engineers and technicians are required. When this project is implemented in a timely manner in relation to the gas processing plant project, it will be possible to make effective use of PTT's human resources.

The organization which would be required for operating and managing the plant is considered in section 5–4 below. The key plant personnel would have to be firstly hired or appointed; they would be the plant manager and plant department managers. It will be necessary to establish a project team consisting of key personnel of plant, led by a project director, in the PTT head office. Then, as progress is made in the project, the staff would be enlarged and organization would be modified to meet the plant construction activities. The organization is transformed so as to be suited for plant operation and management at the later phase of the construction and during initial operation as presented in section 5–4.

In contrast to the situation regarding the organization for the ethylene plant, in the case of the VCM and electrolysis plants, an entirely new organization must be created by the company implementing this part of the project. The products to be sold by this company are to be VCM and caustic soda, so it would be suitable for one of the companies now engaged in production and sales of chlorine and caustic soda in Thailand to participate in this part of the project, prefereably as a joint venture partner with an agency of the Government of Thailand.

This new company should at least for the time being have its head office in Bangkok, and in addition to the head office administrators there should be a project director to head a team forming the nucleus of activity for actually implementing the project and to co-ordinate matters of common interest with PTT's new organization. This company too would gradually build up its staffing level and develop its organization in keeping with progress toward ultimate implementation. Similar to the situation at PTT, this new company is to eventually develop an organization capable of handling all aspects, firstly of plant construction and secondly of plant operation and management.

The oraganizations for project implementation (identical for PTT and the Thai VCM Co.) which are to be established in line with the thinking summarized above, during the initial stage and construction stage, are to be as shown in Fig. V-22. The manning schedule is given as Table V-2.

5–2 IMPLEMENTATION SCHEDULE

5–2–1 Ethylene Plant and Utility Center (PTT)

(1) Evaluation of feasibility study, and government approval

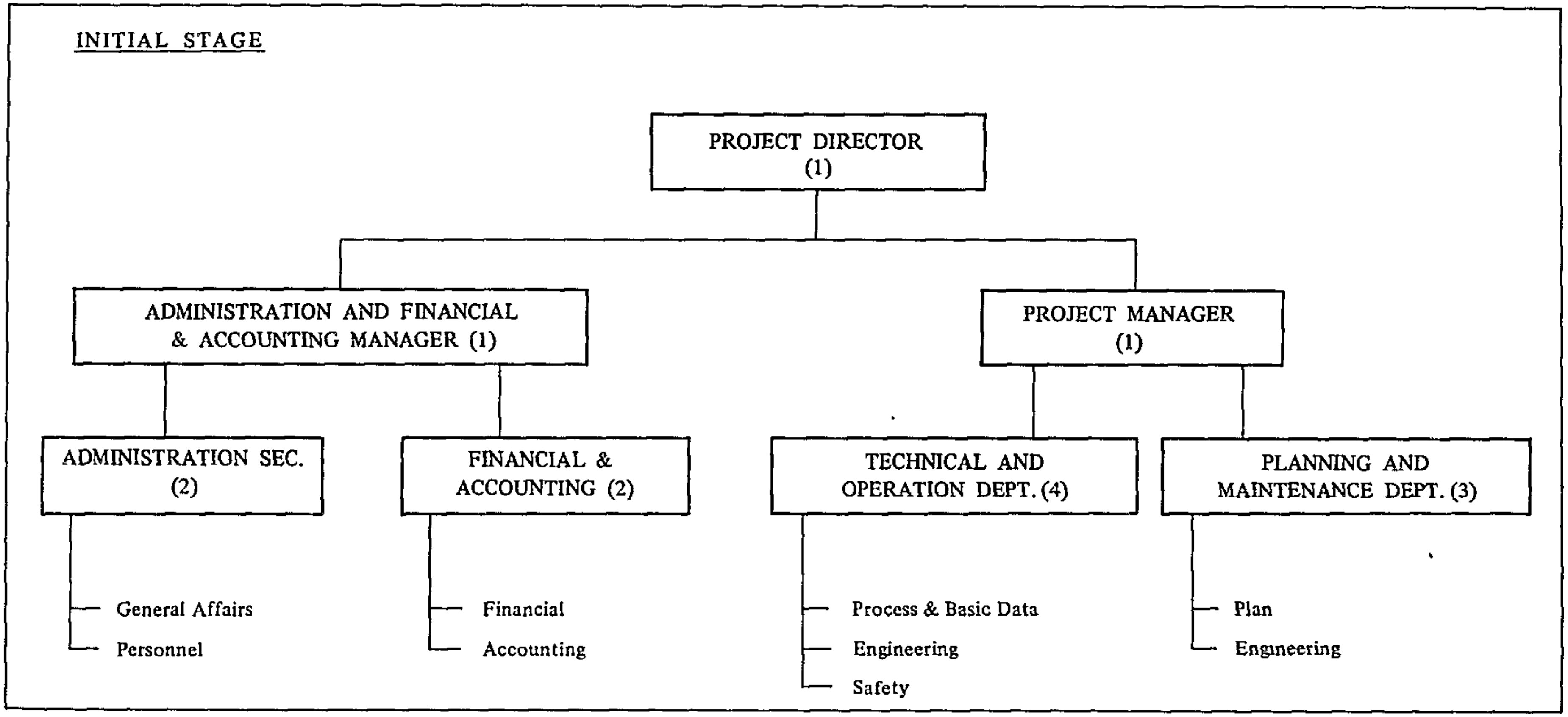
Because PTT already exists and is active as an organization, immediately after the submission of this feasibility study, it would be studied by PTT and submitted to the Government of Thailand for approval. It is expected that this will require three months (i.e., to June, 1981).

(2) Establishing the organization for project implementation

As noted above, it will be necessary to form a project team, led by a project director. The work for establishing the organization for project implementation would be started simultaneously with the review described in (1) above, and be essentially completed by September, 1981.

(3) Financial arrangement

It will be necessary to prepare and submit requests for long-term project financing to the financial institutions concerned; to negotiate loan agreements with them and to undertake the tasks related to securing commitments. (It will be necessary to secure a preliminary commitment by November, 1981 in order to maintain the schedule assumed here.)



Note: Numbers in ( ) show numbers of staff including section chiefs.
Clerks, secretaries, technicians and other supporting personnel are not shown here.

Fig. V–22(A) LIKELY OWNER'S ORGANIZATION

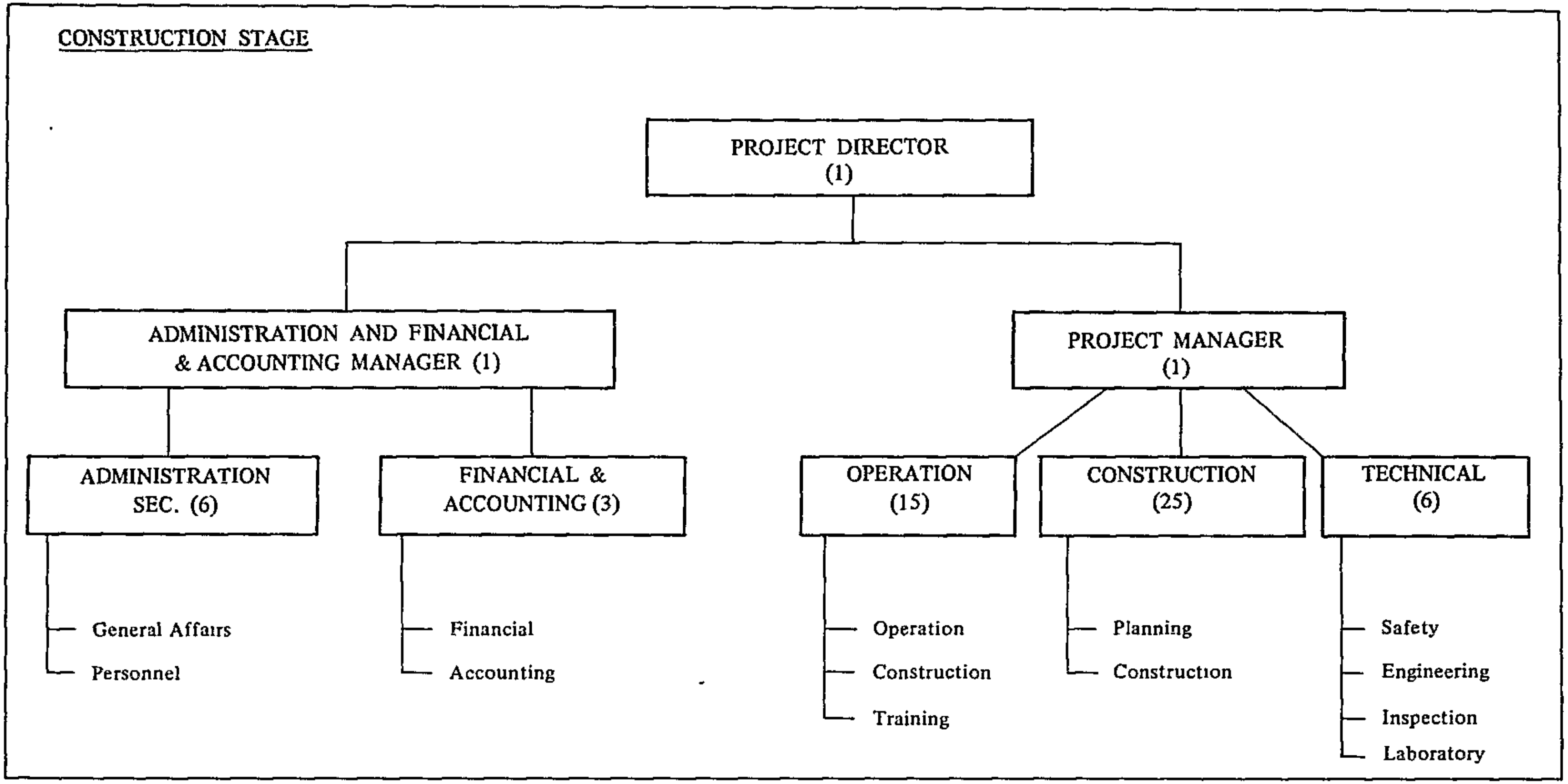


Fig. V—22(B) LIKELY OWNER'S ORGANIZATION

Table V–2 MANNING SCHEDULE

PTT (Ethylene Plant & Utilities Center)

	1981		1982		1983		1984		1985	
Plant Manager		1	1	1	1	1	1	1	1	
Administrative Staff		5	5	10	13	19	23	25	29	
Production		5	8	12	32	48	64	80	80	
Maintenance		3	8	13	27	51	75	81	129	
Technical Operators			3	5	6	14	21	25	46	
Drivers etc.		6	7	9	11	12	14	15	15	
Aides		8	13	16	19	22	29	37	44	
Total		28	45	66	109	167	227	264	344	

Thai VCM Co. (VCM and Electrolysis Plants)

	1981		1982		1983		1984		1985	
Plant Manager			1	1	1	1	1	1	1	
Administrative Staff			5	10	15	22	27	29	34	
Production			9	14	36	54	72	89	89	
Maintenance			6	9	18	34	50	54	86	
Technical Operators			2	3	3	7	10	12	21	
Office Workers			12	15	18	20	27	34	40	
Drivers etc.			7	13	16	18	21	23	23	
Total			42	65	107	156	208	242	294	

Note: Clerks, secretaries, technicians and other supporting personnel and not shown here.

(4) From establishment of design basis to contract award

Use of a turn-key, lump-sum contract is assumed. The milestones from establishment of the design basis to the contract award are as follows.

a. Detailed examination of the design basis
b. Preparation of general terms and conditions for contract
c. Preparation of tender specifications
d. Establishment of bid evaluation criteria
e. Call for tenders
f. Evaluate tenders and select successful bidder
g. Negotiation and award of contract

This period is expected to last 11 motnhs, and because it represents a tight schedule, it is necessary to consider retaining a consultant at the earliest possible time. The contract award would take place at the end of June, 1982.

(5) From contract signing to final acceptance

When a turn-key contract is to be used all construction work is to be performed by and at the responsibility of the prime contractor. For a large-scale project such as the ethylene plant and utilities center, a long time is required before the critical equipment can be erected, and because of the great amount of work to be performed, there is a limit to the progress which can be made in one month. According to what the study team believes to be the most likely estimate, from contract award to mechanical completion it will require 33 months, after which an additional three months will be required for commissioning of the plant and of performance tests. Mechanical completion is expected to take place in March, 1985, and plant acceptance is expected to take place at the end of June, 1985. Therefore, commercial operation will begin in July, 1985.

During these periods it will be necessary for the owner to supervise the work of the prime contractor to prepare for plant operation, set up the required organization, hire and train personnel, prepare a financial plan and obtain loan commitments, arrange for purchase of raw materials and utility supply service, negotiate product sales contracts and many other tasks.

After the completion of construction, the project will enter the initial start-up stage. Until plant acceptance, operation of the plant will be performed by the contractor's operation team. It will be effective for the owner's personnel to obtain experience by participating in the field work from the state of tests and flushing prior to start-up. Inital operation will also be performed by the contractor but it is desirable to have the owner's personnel join in the work.

The implementation schedule for the ethylene plant and utilities center portion of the project is shown in Fig. V-23.

(6) Alternative schedule

The project schedule described above is based upon the "turn-key lump-sum" contract under which a single contractor will perform every phase of the project until the plants are completed.

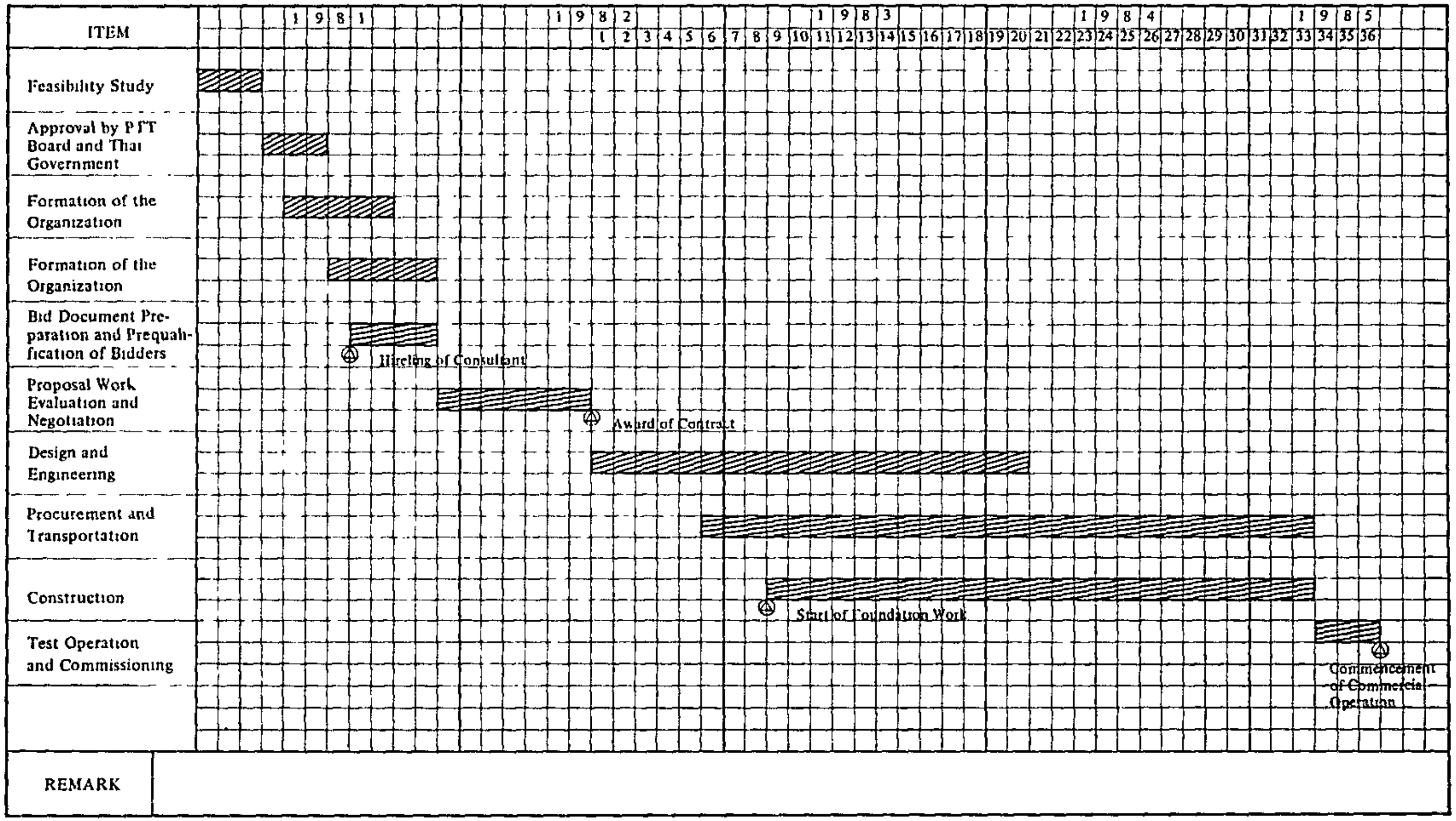
It is, therefore, of vital importance to select the contractor and this schedule allocates 11 months as minimum from the establishment of design bases to selection of the contractor and award of the contract.

If this project is phased into two steps; the first phase being the basic design and engineering, and the second phase procurement and construction; and is executed in timely manner, the overall project schedule may be shortened.

In the first phase the project owner shall select an engineering firm to perform basic and detail engineering work. Evaluation of the latest process licenses and capability of the prospective engineering companies is to be carried out. The period required for the evaluation and selection of the engineering firm, however, will be less than that for the "turn-key lump-sum" cotractor. The selection of licensor and engineering company may be completed within 5 months (December, 1981). This enables the design/engineering work of the project to be commenced from January, 1982.

The second phase of the project (procurement and construction) may either be proceeded under the "reimbursable cost" contract or "lump–sum" contract. It is expected that the second phase project proceeds within the same period allocated for "turn-key lump-sum" case. The completion of the project (plant acceptance) may be 6 months earlier compared to the base case, enabling the commercial operation of the plant to start from January, 1985.

Fig. V—23 ETHYLENE PLANT IMPLEMENTATION SCHEDULE



5–2–2 VCM and Electrolysis Plants (Thai VCM Co.)

(1) Evaluation of the feasiblity study, and government approval

It will be necessary to proceed with evaluation by PTT and obtain government approvals in similar manner to, and simultaneously with, the same procedures for the ethylene plant.

(2) Establishment of the company to undertake the venture

After the government has approved the VCM and electrolysis plants portion of the project, preparations must be made for establishment of the company which will construct and operate the plants and sell their products. As noted above, there will probably be a joint ventrue established by PTT and private sector interests from Thailand and/or other countries (and, if necessary, with participation by other governmental agencies). After such a joint venture has been established, it would carry on work which had been begun by PTT.

(3) Financial arrangements, establishment of design criteria and contract award

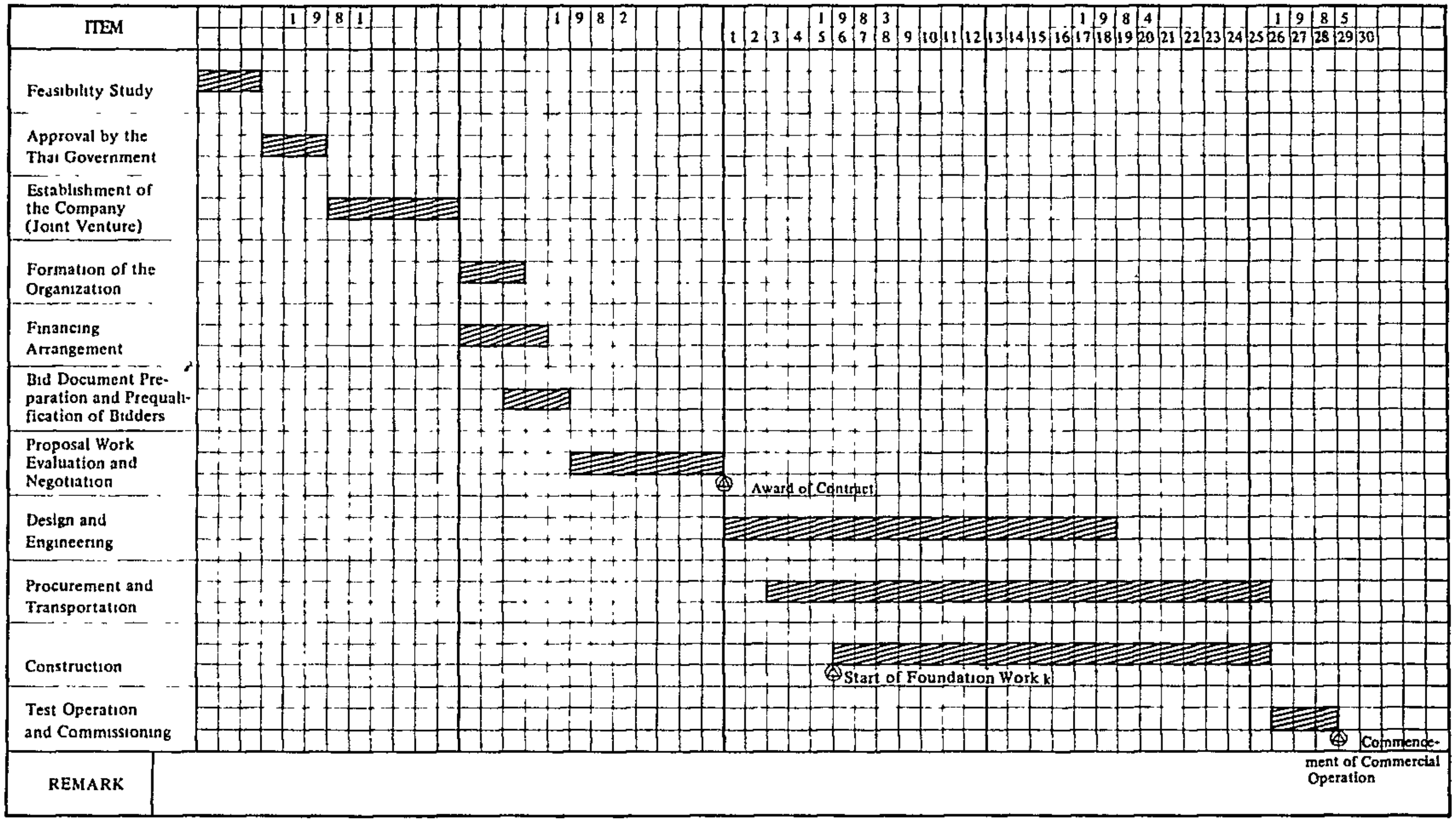
The making of financial arrangements, establishment of design criteria, and award of contract would be done almost in the same manner as in the case of the ethylene plant. Contract signing would be at the end of November, 1982.

(4) From contract signing to final acceptance

It is assumed that a turn-key lump-sum contract will be used. The work from engineering through completion of construction is to be done by the prime contractor. The VCM and electrolysis plants comprise a medium-scale project, and from contract award to mechanical completion 28 months will be needed (i.e., this will take until March, 1985) and an additional three months will be needed prior to plant acceptance (in June, 1985). During this period, the owner will have to accomplish a great many tasks, including supervision of the prime contractor; hiring and training of personnel; preparation for plant operation; borrowing of funds; signing of sales contracts; signing contracts for raw materials and utilities supply and so on.

The implementation schedule for the VCM and electrolysis plants is as shown in Fig. V-24.

Fig. V–24 VCM PLANT IMPLEMENTATION SCHEDULE



5–3 CONSTRUCTION PLAN FOR THE PROJECT

5–3–1 Ethylene Plant and Utilities Center (PTT)

(1) The construction period for the ethylene plant and utilities center, encompassing the civil construction work followed by mechanical, electrical and instrumentation work, etc. will be 25 months. This is the most likely estimate, based on past performance for construction of ethylene plants.

(2) According to the estimate of the work volume, the gross weight of the materials required for the ethylene plant and utilities center will be:

Equipment, materials	18,100 tons
Construction materials	5,100 tons
Total	23,200 tons

Steel reinforcement bars, cement and other materials for civil construction are not included in the above. The materials are to be landed at Sattahip and then transported overland to the site.

The largest single item is the ethylene fractionator which will measure approximately 3m in diameter and 70m in height; it will weight about 170 tons. Its length, 70m, is too long to permit it to be transported overland to the site and it will be fabricated in two parts which will be welded at site before installation.

(3) Construction equipment required will include in addition to a gin pole for installation of large towers, cranes (11 cranes, from 15 to 120 tons), trucks (four) and forklifts (five).

(4) Construction work will be performed by a management organization of the prime contractor, with key personnel consisting of expatriate specialists. Construction planning, schedule control, cost control and quality control are to be the sole responsibility of the contractor's field manager.

5–3–2 VCM and Electrolysis Plants (Thai VCM Co.)

(1) Construction scale is smaller than that for the ethylene plant; the construction period including civil work and everything up to mecahnical completion is expected to be 22 months.

(2) According to the estimate of work volume, the quantity of materials required for the VCM and electrolysis plants combined is about 18,500t (excluding materials for civil construction). The same as in the case of the ethylene plant, the materials are to be landed at Sattahip and transported overland to the site.

(3) A construction management organization independent of that of the ethylene plant will function on behalf of the VCM and electrolysis plants owner.

5–4 ORGANIZATION FOR PLANT OPERATION AND MAINTENANCE

The organization which will be required for operation and maintenance of PTT's ethylene plant and utilities center, as well as the Thai-VCM Company's VCM and electrolysis plants, is as shown in Figs. V-25 and V-26.

These organizations are to be composed of administrative, production, maintenance and inspection, and technical services division.

The ethylene plant, including the utilities center, will employ 344 persons. The VCM and electrolysis plants will employ 294 persons, for a total of 638 employees. These figures do not include employees at the head offices in Bangkok. Therefore, for financial and economic analysis, a separate accounting was made of the cost of head office employees. All of these employees must be hired by April, 1985, when test operation begins, in accordance with the manning schedule presented before.

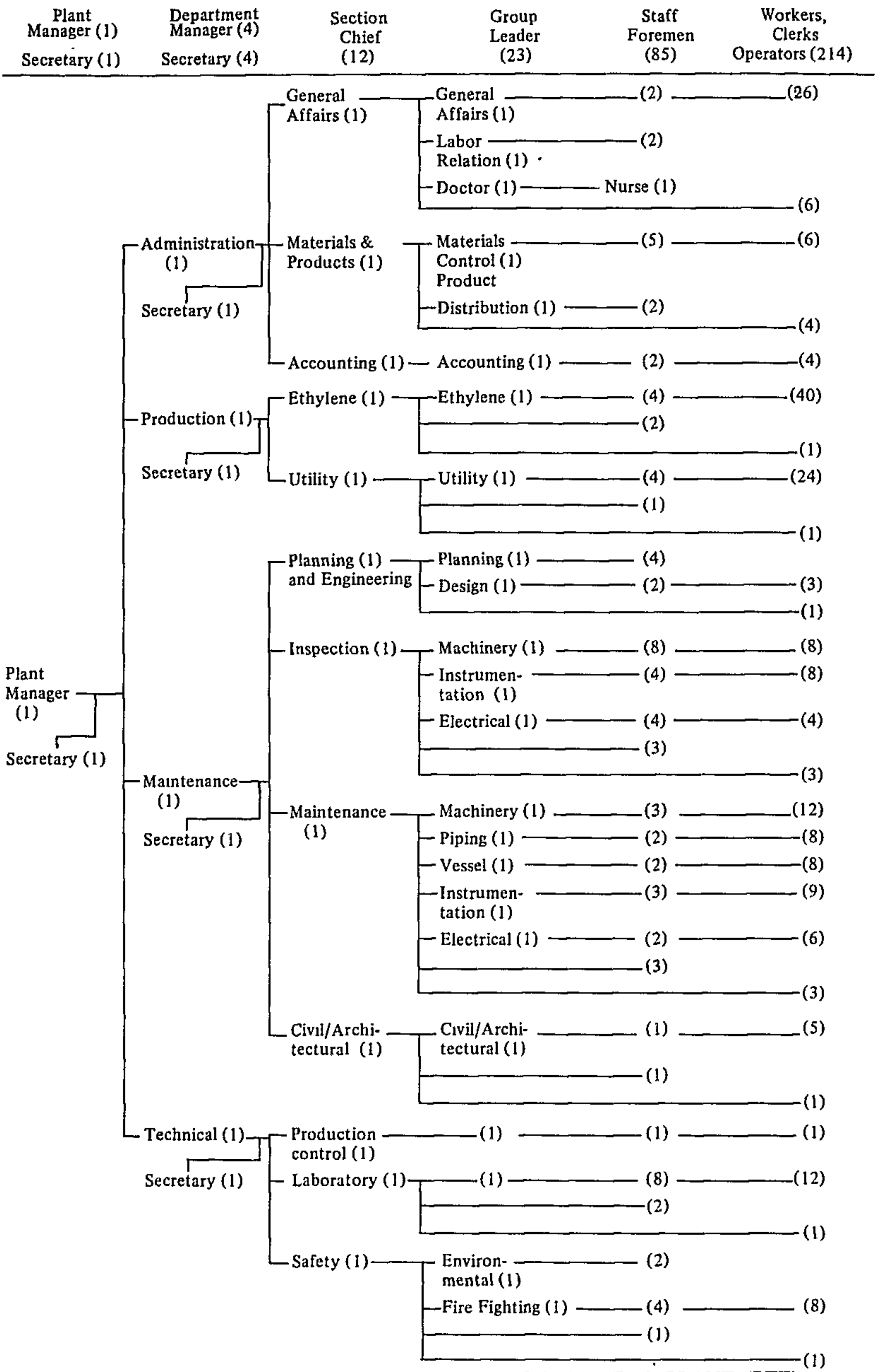


Fig. V-25 ORGANIZATION CHART FOR THE ETHYLENE PLANT (PTT)

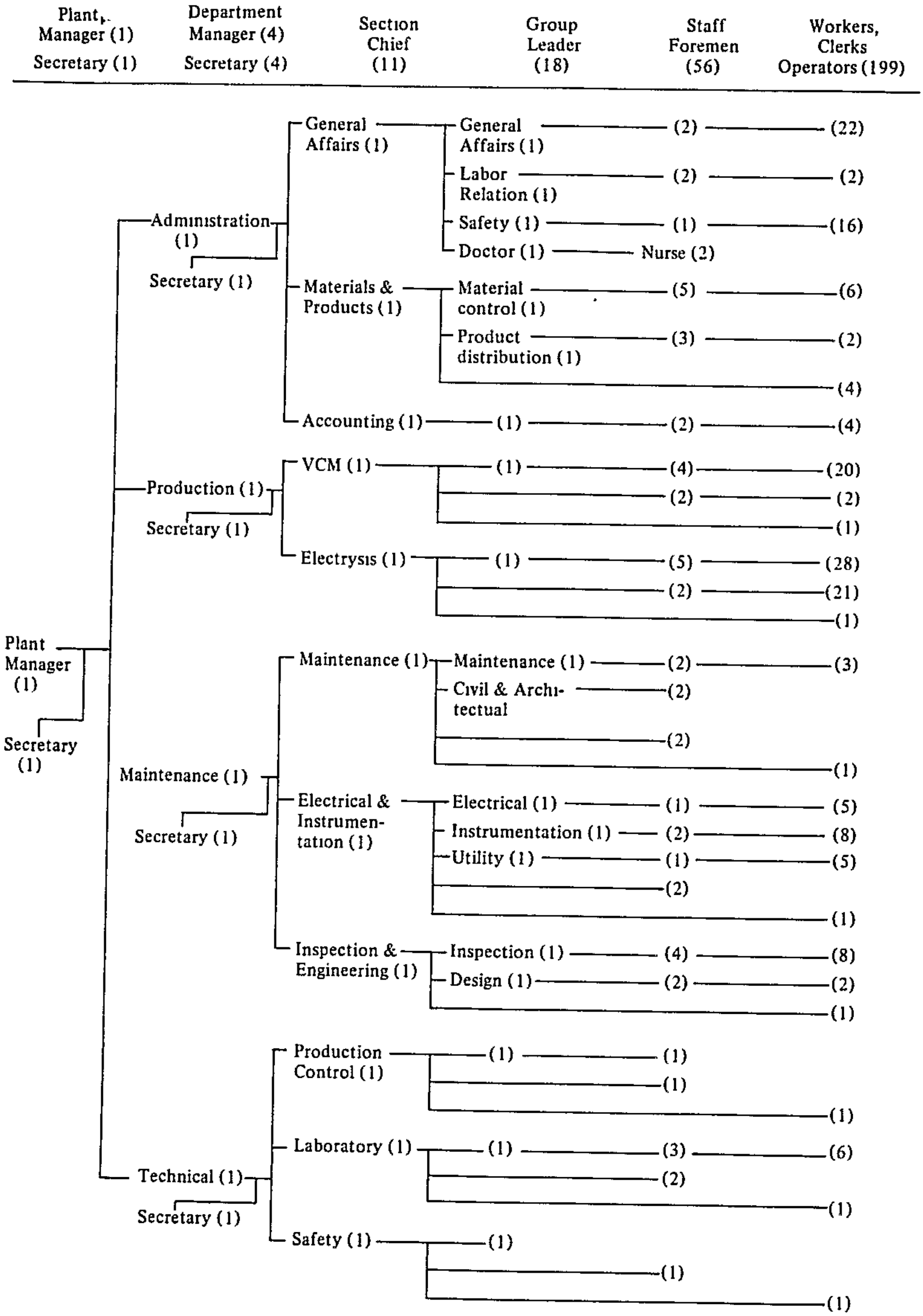


Fig. V–26 ORGANIZATION CHART FOR THE VCM AND ELECTROLYSIS PLANT (THAI VCM CO.)

5–5 TECHNOLOGY TRANSFER AND TECHNICAL ASSISTANCE SERVICES

5–5–1 General

Operation of the petrochemical complex requires workers with advanced skills, and because industrial projects as technologically sophisticated as this one are yet to be constructed in Thailand, training of workers, i.e., transfer of technology, is the most important aspect of this project related to personnel. This is also highly desirable from the economic viewpoint of reducing and minimizing the need to utilize expatriate experts to assist in operation of the petrochemical complex. Information on a desirable arrangement for transfer of technology is provided below, and this study assumes that such an arrangement will in fact be realized.

5–5–2 Human Resources Development

Because it is expected that it will not be possible to hire workers having the proper qualifications and experience, it is expected that it will be necessary to establish a training program for newly-hired graduates from colleges and technical schools.

The training program must be implemented in coordination with the start-up schedule for the petrochemical complex, in order to facilitate assignment of the right persons to the right posts, and start the project smoothly. Moreover, the training program should be implemented in the following phases.

Phase I: Training in Japan

The training in Japan is of critical importance in attaining success in the transfer of technology.

Phase II: Training in Thailand

After completion of Phase I, the trainees who have received training in Japan will study software manuals, texts, etc. in Thailand, under the supervision of experts desptached from Japan. This training should be done at a training center provided with suitable facilities.

Phase III: On-the-job training

When the project enters the test flushing and initial operation phase, there will be an opportunity to obtain valuable on-the-job training under the supervision of expatriate experts, in testing, flushing, and other work. This is a particularly good opportunity to gain experience because when equipment is used for the first time, difficulties of one kind or another are commonly encountered and require on-the-spot action to eliminate. It is therefore anticipated that a considerable number of operators and technicians will become qualified for their work in the commercial operation phase through this experience.

5–5–3 Assistance by Expatriates

After performance tests of the plants and facilities are completed, for the first six months of commercial operation the assistance of expartriate experts for the operation of the petrochemical complex, and for training of employees, will be needed. During this period, the training program will be completed, and thereafter the plant personnel will be able to perform on-the-job training as required without outside assistance. During this period, the experts would concentrate on establishing the following control systems:

Quality control
Process control
Equipment and facilities maintenance control
Warehouse management
Cost control
Safety assurance management

Establishment of these systems will enable the workers to economically and continuously operate the petrochemical plants and facilities without outside assistance.

CHAPTER 6 ENVIRONMENTAL PROTECTION

6–1 INTRODUCTION

It is aimed in this study that the petrochemical complex being planned at Rayong district shall utilize the latest technology available and shall form by itself a totally enclosed system to achieve conservation of resources and energy, and environmental protection.

This petrochemical complex will, therefore, basically be pollution free, eliminating the hazardous substances within its process plants and preventing their discharge to the environment.

In this study, the plants are planned and designed based upon the Japanese regulations for environment protection which are regarded as the most severe in the world. Environmental standards of Thailand are also applicable to this study with a few exceptions which are considered inadequate from the technical as well as economical viewpoints. (Refer to section 6–3 for details)

In the planning of environment protection measures the following steps are adopted.

(1) Confirmation of sources of pollutants

By study of design of each plant to be included in the complex, the quantities and nature of wastes which would be produced were evaluated (See section 6–1).

(2) Establishment of standards for pollution prevention and control.

To prevent any pollution caused by the operation of the complex, standards are to be established for waste gas and effluent. The standards so established are based on applicable laws and regulations in Japan, standards in Thailand, and the applicability of pollution prevention and control technology (See section 6–2).

(3) Design of pollution prevention facilities

Waste treatment and disposal methods and facilities necessary to achieve the environment protection targets (for waste gas and effluent emission) are designed in accordance with the standards as established above. For this design, the optimum combination of two methods was considered to be adopted; those two methods are: (a) control over generation of wastes, by improvement of processes (including change of the design of equipment) and (b) containment, whereby to the greatest extent possible wastes are to be processed and contained at their sources.

6–2 WASTES FROM THE ETHYLENE, VCM AND ELECTROLYSIS PLANTS, AND THE UTILITIES CENTER

6–2–1 General

From the detailed material balance the quantities and nature of wastes including pollutants were confirmed. Studying the sources and nature of wastes makes it possible to establish pollution prevention measures. To insure proper operation of the complex, technology which has been proven in existing plants including utilities plants and pollution prevention plants, is to be used.

6–2–2 Ethylene Plant Wastes

The ethylene plant is designed to form a closed system from the requirements of energy conservation as well as:

(1) Minimizing the waste effluents.

(2) Treating each waste effluent at the origin and making best use of it. The quantity of quench water blow-down, for example, has been greatly reduced as compared to the conventional plant. As the various schemes like this have been applied to the latest ethylene plant the waste effluents to the outside are minimized or are almost nonexistent.

As shown in Fig. V-27, effluent and gaseous emissions are generated when the ethylene plant is operated under normal conditions.

The major liquid phase effluents from the ethylene plant are as follows.

(1) Quench water blow-down

Steam is mixed with ethane as a diluent prior to pyrolysis. Most of the condensate of this steam, called "quench water," is recycled for generating steam. To prevent scale, part of the condensate is replenished with fresh water (make-up water). The water which is removed from the cycle is called quench water blow-down. Recycling of the remainder reduces the required capacity of the effluent processing facility. The blow-down is permitted to cool before conveyance to predisposal processing facility.

(2) Spent caustic soda solution

Cracked gas is washed by caustic soda solution to remove acid gas (mostly carbon dioxide). The spent caustic from this and wash water are sent to the effluent processing

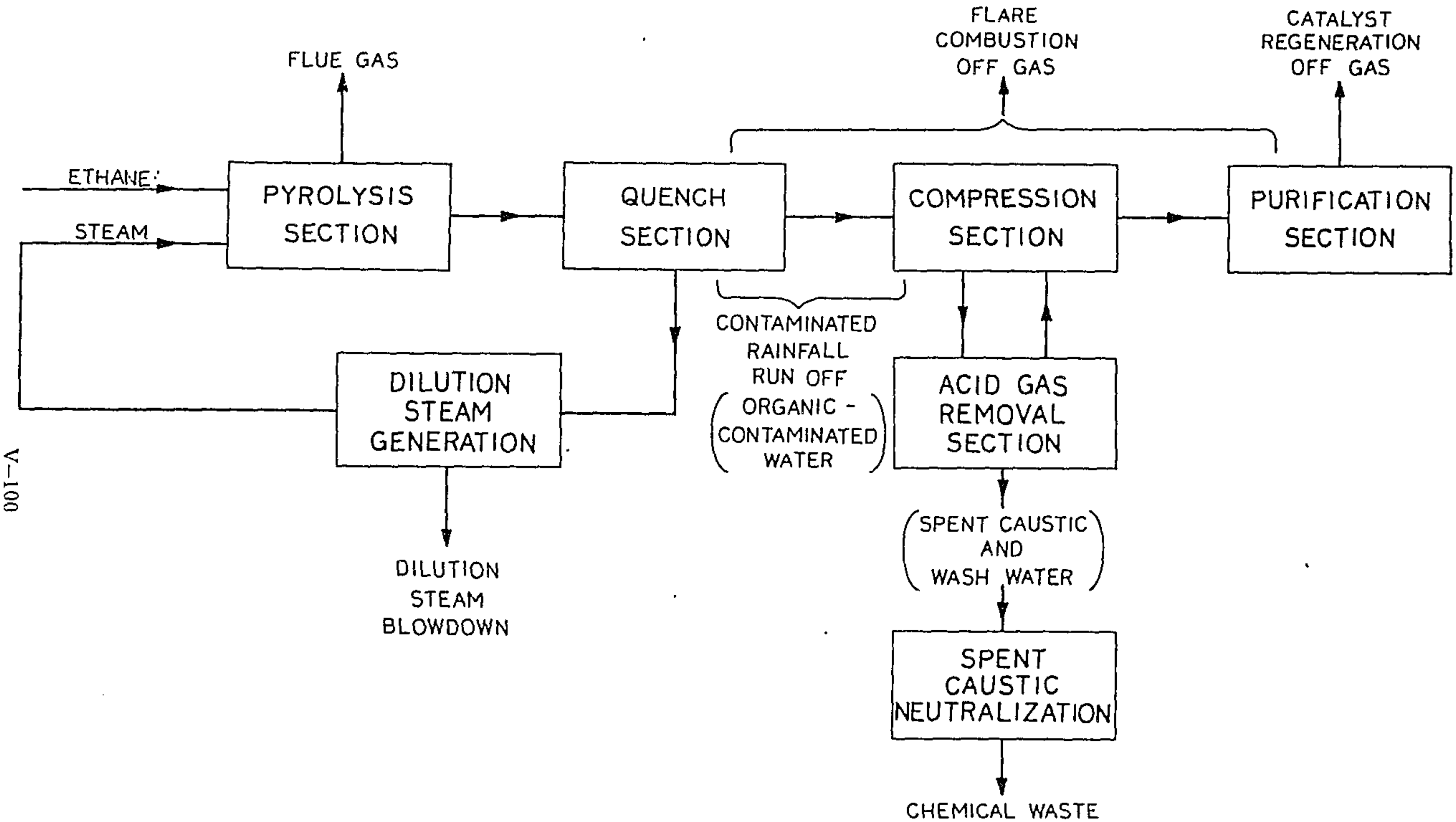


Fig. V—27 ETHYLENE PLANT BLOCK FLOW DIAGRAM facility after neutralization with dilute sulfuric acid. The spend caustic after neutralization only contains 5~10% sodium sulfate.

(3) Boiler water blow-down

A high-pressure boiler is installed to recover waste heat from the cracking furnace. To prevent scale, part of the boiler water is changed. The blow-donw in reused as caustic wash water.

(4) Surface runoff containing oil

Surface runoff contaminated with oil in the area of the facilities is collected in the waste water pit, then conveyed to the centralized waste water treatment facilities.

Regrading waste gas from the ethylene plant, control of the concentration of pollutants in gaseous emission from the plant is carried out at each source of emissions. The waste gases, the processes whereby they are produced, their nature and control methods are described as follows.

(1) Cracking heater flue gas

Cracking heater flue gas is the waste gas generated in largest quantity. It contains no sulfur compounds as natural gas is used as fuel and therefore no SO_x is released. NO_x content is below 100 ppm. This figure clears the emission limit for the boilers of equivalent flue gas quantity; however, it is not regulated in Japan.

(2) Catalyst regeneration off-gas

Two reactors for selective hydrogenation of acetylene are installed in the ethylene plant (one for standby use). During normal operation carbon is deposited on the catalyst, reducing the activity of the catalyst. Therefore, operation is stopped at regular intervals and the catalyst is regenerated. Before regenerating the catalyst, the carbon deposits are stripped by injection of steam, and are sent to a blow-down stack to be burned. Therefore, no carbon is released. During catalyst regeneration, carbon is only burned, so no pollutant is released.

(3) Blow-down flare stack gas

The gaseous hydrocarbon is not purged out during normal operation, however, the large scale flare stack is furnished to treat the gas by complete combustion in case the gas should be released during start-up operation or emergency. To prevent smoke atomizing steam is introduced. NO_x content in flare gas is less than 100 ppm.

6–2–4 Electrolysis Plant Wastes

The ion-exchange membrance process is to be used in the electrolysis plant. Because it does not use mercury or mercury compounds, no pollution can be caused by that element. The solid wastes present in effluent from the plant are the same as usually present in sea water and will cause no pollution.

Effluent from the plant comprises the following:

Pressed filtrate
Primary brine filter waste water
Secondary brine waste water
Hydrogen drain
Chlorine drain

Major properties of these are as follows:

		Properties	Regulated value
Pressed filtrate	NaCℓ	250–300 g/ℓ	
	pH	9 – 11	5 – 9
Primary brine waste	NaCℓ	About 300 g/ℓ	
	pH	10 – 11	5 – 9
Secondary brine waste	NaCℓ	about 300 g/ℓ	
	pH	10 – 11	5 – 9
Hydrogen drain	pH	7 – 10	5 – 9
Chlorine drain	Dissolved chlorine	1 – 6 g/ℓ	Free $Cℓ_2$: 1 mg/ℓ

As shown in the negative flow sheet (Fig. V-29), the electrolysis plant is a fully closed system which does not pollute. There is no emission to outside the plant, and through its function of recovering salt, alkali and chlorine, it conserves the use of raw materials.

As shown in the negative flow sheet (Fig. V-30), waste gases are emitted from the plant's sodium hypochlorite section. This gas, however, is almost the same as air in composition, as the purpose of this section is to remove chlorine from the waste gas flows from the plant's production sections at times of emergency and start-up. No chlorine is detectable in the emission from this section.

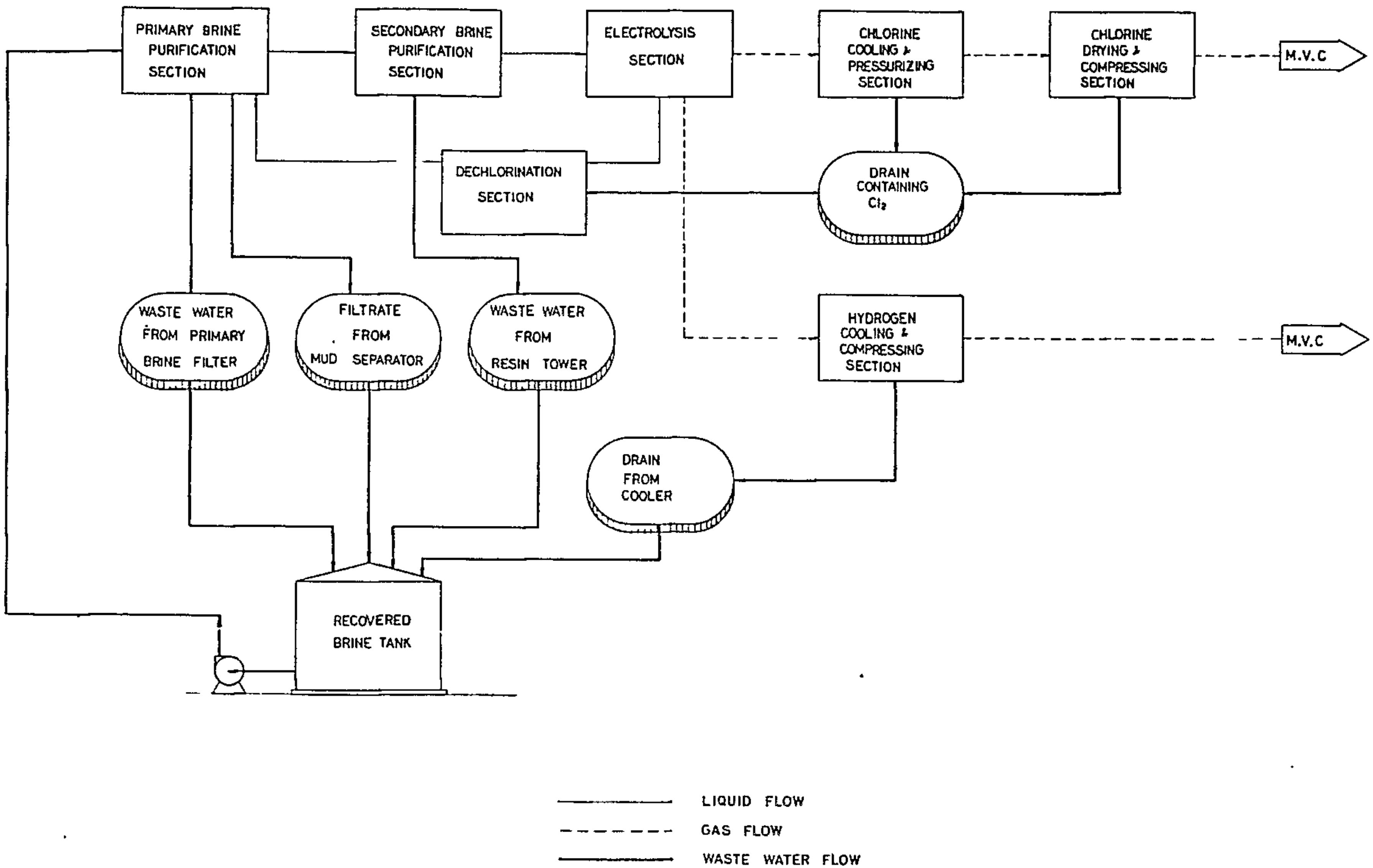


Fig. V–29 NEGATIVE FLOW SHEET OF WASTE WATER (ELECTROLYSIS PLANT)

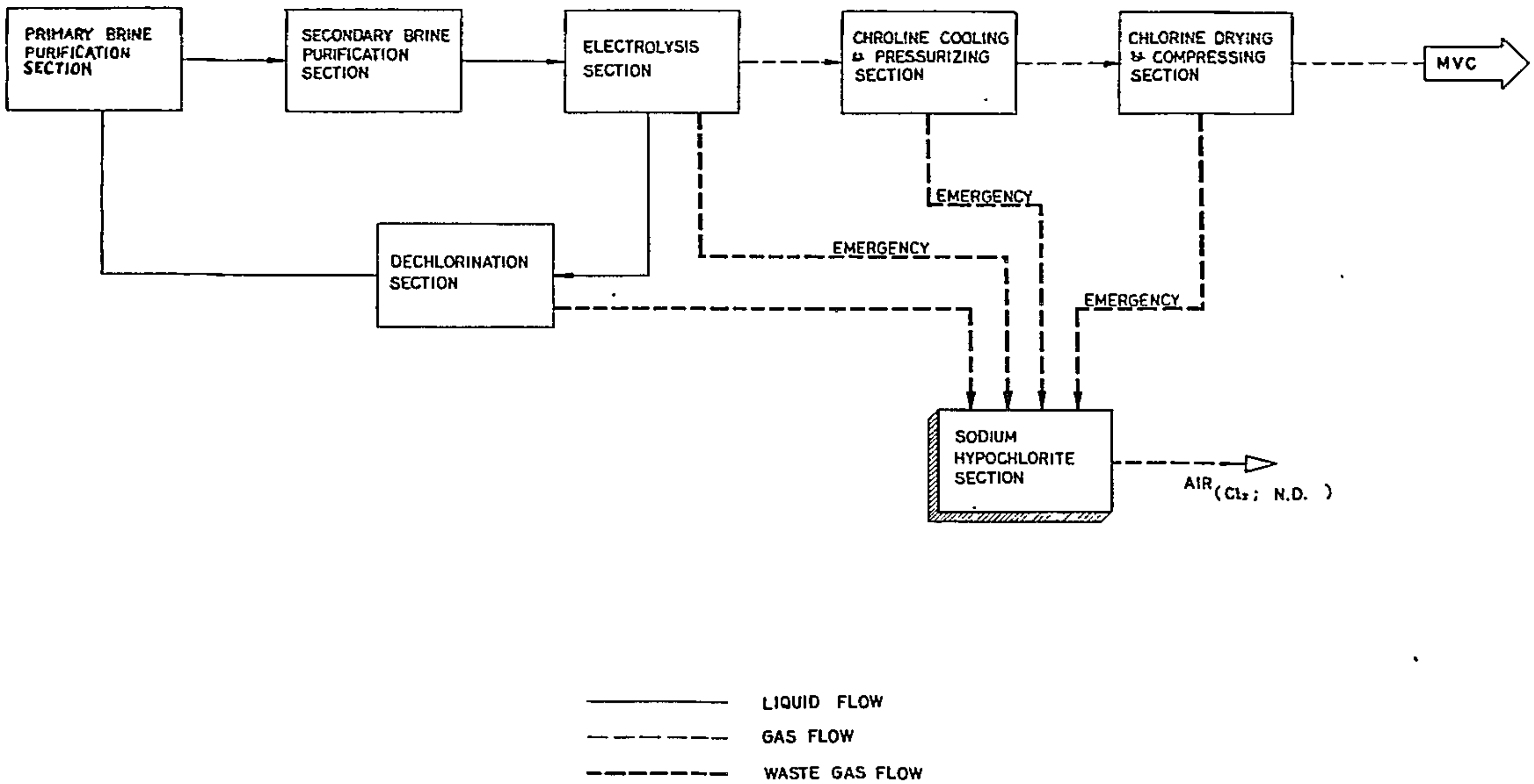


Fig. V—30 NEGATIVE FLOW SHEET OF WASTE GAS (ELECTROLYSIS PLANT)

The quantity of gas emitted from this section is about 600 m^3/hr; the acceptable limit of chlorine is 30 mg/Nm^3 but as noted before, no chlorine is detectable in the gas.

As shown in the negative flow sheet for solid waste (Fig. V-31), brine mud is produced as electrolysis plant waste, as a result of removal of impurities from brine. It consists of harmless matter such as calcium carbonate and magnesium hydroxide.

Brine mud is produced at the rate of about 6 t/d (when chlorine production is 48,000 t/y). Because it is harmless, there are no values by which it is to be regulated.

6–2–5 Utility Facilities Waste

The utility facilities will generate the following emissions and effluents.

Facility	Wastes	Pollutant
Boiler water purification facility	Water blow-down	Salts
Cooling tower	Water blow-down	Salts
Boiler	Water blow-down Fuel vent gas	Salts NO_x
Gas turbine	Fuel vent gas	NO_x

Effluent from the utilities facilities includes only salts, in a slightly higher concentration than usual industrial water, and it is not necessary to send the effluent to the processing facility. There will be no water pollution problems.

The fuel used is processed natural gas; because the processing removes sulfur, no SO_x is contained in flue gas from the energy section of the utilities facilities. The concentration of NO_x in gas from the gas turbine is 130 ppm, and that in gas from the boiler is 100 ~ 130 ppm (the latter value ranges depending upon the use of a low-NO_x burner).

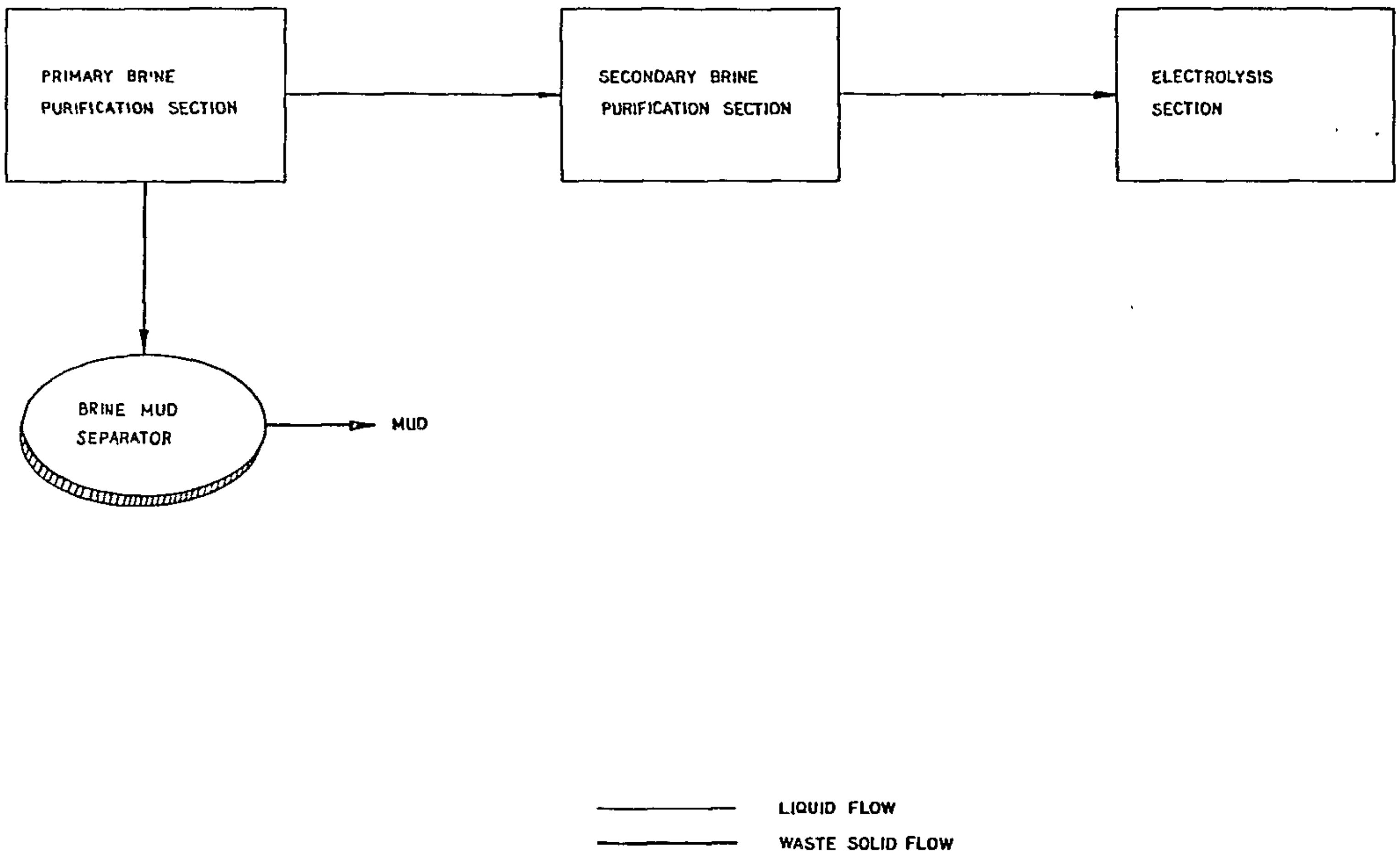


Fig. V—31 NEGATIVE FLOW SHEET OF WASTE SOLID (ELECTROLYSIS PLANT)

6-3 ENVIRONMENTAL PROTECTION STANDARDS

6-3-1 General

Environmental protection standards for the petrochemical complex are devised from the standpoint of view of insuring the most efficient operation of the complex and the highest degree of protection of the environment, by taking into consideration the following.

(1) Pollutant control levels are to be established and applied to waste products from the complex.

(2) Existing Thai environmental protection stadards are to be applicable.

(3) The Japanese statutory requirements regarding pollution control are to be applicable.

(4) The most widely adopted technology is to be utilized.

6-3-2 Air Pollution Control Standards

Pollutants from the complex and the respective countermeasures are as shown below. Note should be made that Thailand does not at present have statutory requirements concerning such emissions.

Air pollution abatement

Pollutant	Countermeasures Considered
Chlorine	Control emission by caustic soda washing
Hydrochloric acid	Control emission by caustic soda washing
NO_x[1]	Control generation by use of a low-NO_x burner; use of NO_x elimination facility is not considered necessary
Soot	Generation of soot to be controlled by regulation of combustion. Precipitators etc. are not needed.
SO_x	No SO_x is generated because the fuel gas is sulfur-free.

1) A de-NO_x process to reduce emission of NO_x to 40 ppm is available. However, in this project, as the plant is to be located in a sparsely- populated and -industrialized area, it is not considered necessary to provide it with the De-NO_x. A 130 ppm NO_x without treatment may be acceptable, because in most of the industrialized countries the De-NO_x unit is installed only in heavily populated and industrialized locations.

Sandards for emissions into the atmosphere are established for this study as follows

Atmospheric emission standards

Emission	Source Facility	Standard (Maximum)
Chlorine[1)]	Electrolysis plant	5 ppm
Hydrochloric acid[1)]	Electrolysis plant, VCM plant, Incinerator	5 ppm
NO_x[2)]	Gas-fired boiler	130 ppm
Soot[3)]	Gas-fired boiler Incinerator	0.20 g/Nm^3 0.70 g/Nm^3

1) 5 ppm can be easily attained by caustic soda washing and this figure clears the emission limit in Japan.

2) NO_X is said to be a cause of photochemical smog. In Japan, environmental standard limit of NO_2 is 0.04 ppm (in Thailand, by Ministry of Industry Notification 1979, this figure is 0.32 mg/m^3). However, that of NO_X is regulated case by case depending upon type of industry or facility, and the gas-fired boiler is only regulated at present (no regulation for NO_X exists in Thailand). In this project, therefore, the conceptual design for boiler is made in accordance with the standard in Japan. The minimum figure to be attained by up-to-date low NO_X burner which will clear "the limit for the existing facility" in Japan may be recommendable, because the limit applied for the facility to be newly built is not accomplished by adopting only low NO_X burners.

3) Based on the permissible limit in Japan, because there is no specific requirement in Thailand.

6–3–3 Waste Water Control Standards

Waste water control standards are determined on the basis of the following:

(1) Treated waste water is to be discharged into the ocean through the sewer.

(2) The following processes are to be used to prevent or reduce pollutants in waste water.

Waste Water Control Standards

Process	Function
Primary processing	
Gravitational separation of oil (CPI oil separator)	Removal of oil
Coagulative flotation	Remove floating suspended solids
Coagulative sedimentation	Remove finely suspended solids
Filtration	Remove suspended solid
Secondary processing	
Activated carbon adsorption	Removal of matter causing COD

(3) Biochemical treatment methods are not employed because of operational reasons expected in Thailand and the nature of the effluent

The standards for waste water control are set up in this study as shown below:

Standards for waste water

Effluent item	Standard
pH[1)]	5 – 9
BOD[1)]	50 mg/l
COD[2)]	100 mg/l
Suspended solids[1)]	30 mg/l
Total dissolved substances[3)] (TDS)	Not regulated
Oil and grease[1)]	5 mg/l
Phenols[1)]	1 mg/l
Copper[1)]	1 mg/l
Zinc[1)]	5 mg/l
Free chlorine[1)]	1 mg/l
Temperature[1)]	40°C

1) These standards accord with those of Ministry of Industry Notification (1979) in Thailand.

2) According to the statutory limit of Ministry of Industry Notification (1979) in Thailand, permanganate value is regulated to be less than 60 mg/l, which is equivalent to 15 mg/l of COD. However, this is not considered realistic not only from technical but also from the economical points of view. Therefore, taking into account regulations for COD in most of the industrialized countries, the figure of 100 mg/l was adopted as the limit, which clears COD regulation in Japan.

3) According to the statutory limit of the Ministry of Industry Notification (1979) in Thailand, TDS is regulated to be less than 2,000 mg/l. But at present technology for measurement of other than salts has not been established. Moreover, because effluent is discharged directly into the ocean, it was decided that TDS would not be regulated. There is no regulation for TDS in Japan.

6–4 POLLUTION PREVENTING SYSTEM TO MEET THE ENVIRONMENTAL PROTECTION STANDARDS

6–4–1 Air Pollution Preventing Facilities

The following measures are to be adopted to prevent air pollution.

Air pollutant	Source Facility	Measures
NO_x [1]	Boiler	Use low-NO_x burner
Hydrochloric acid	Incinerator	Caustic soda washing
Chlorine	Incinerator and Electrolysis plant	Caustic soda washing

6–4–2 Central Waste Water Treatment System

Effluent from the plants is to undergo a primary treatment in the plants where it is generated, and if required will undergo further treatment in the centralized waste water treatment facilities provided in the utilities center which will treat the waste water so that it conforms to the standards set forth here prior to being discharged into the ocean. The overall scheme for treatment of waste water is shown in Fig. V-32.

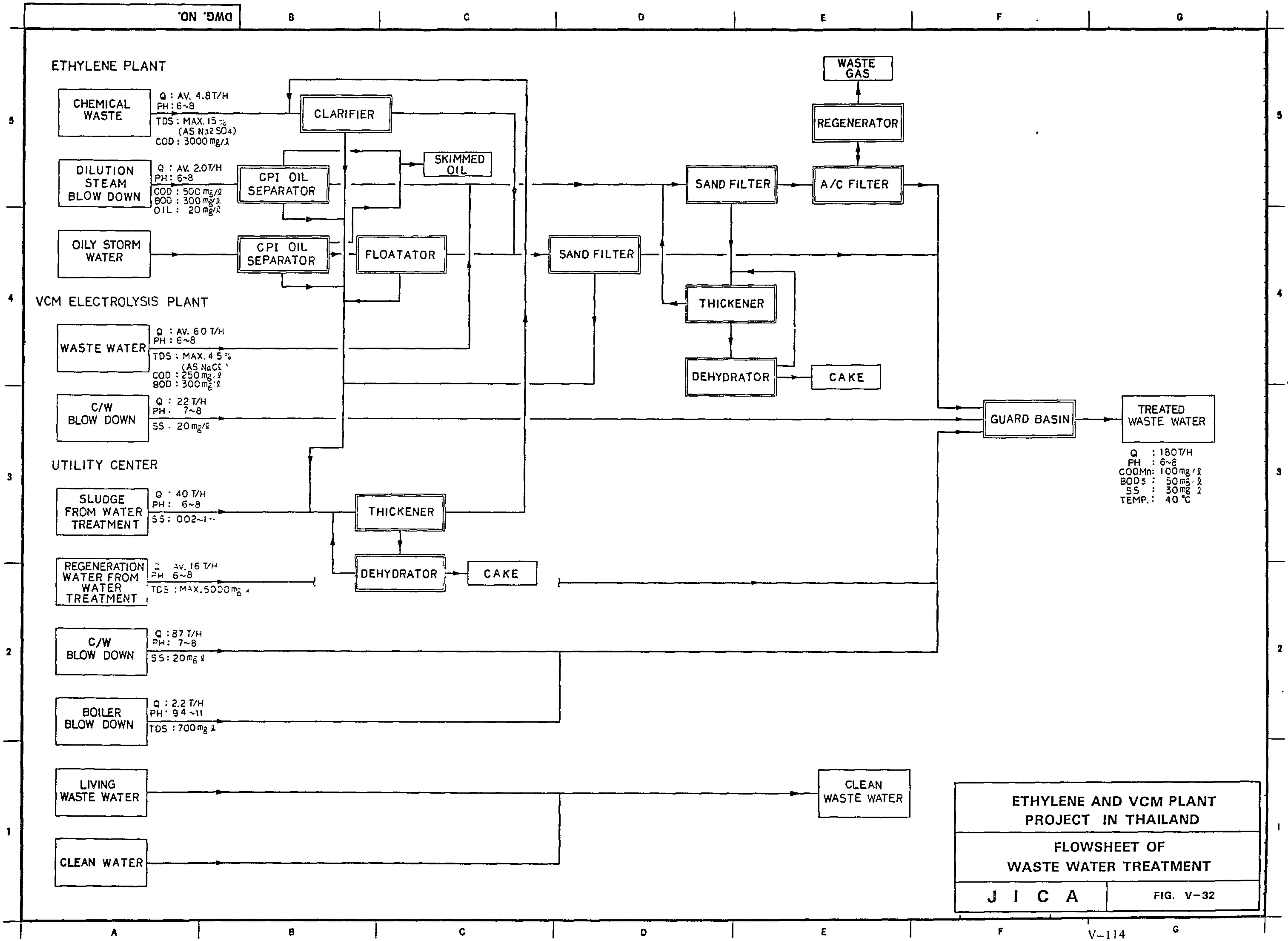
(1) Spent caustic soda solution from the ethylene plant

Spent caustic soda solution from the ethylene plant is passed through the clarifier, then the sand filter to the guard basin.

(2) Quench water blow-down

Oil is separated out in the CPI oil separator; the blow-down is then passed through the sand filter and subjected to activated carbon adsorption in order to reduce COD.

1) No special measure is provided for the cracking heaters, because as stated in the subsection 6–2–2 above, NO_X content in the fuel gas from the cracking heaters is less than 100 ppm and no regulation exists in Japan.


DWG. NO.
ETHYLENE PLANT
CHEMICAL WASTE
Q : AV. 4.8T/H
PH : 6~8
TDS : MAX. 15 %
(AS Na2SO4)
COD : 3000 mg/l
CLARIFIER
DILUTION STEAM BLOW DOWN
Q : AV. 2.0T/H
PH : 6~8
COD : 500 mg/l
BOD : 300 mg/l
OIL : 20 mg/l
CPI OIL SEPARATOR
SKIMMED OIL
OILY STORM WATER
CPI OIL SEPARATOR
FLOATATOR
SAND FILTER
SAND FILTER
WASTE GAS
REGENERATOR
A/C FILTER
THICKENER
DEHYDRATOR
CAKE
VCM ELECTROLYSIS PLANT
WASTE WATER
Q : AV. 60 T/H
PH : 6~8
TDS : MAX. 4.5 %
(AS NaCl)
COD : 250 mg/l
BOD : 300 mg/l
C/W BLOW DOWN
Q : 22 T/H
PH : 7~8
SS : 20 mg/l
GUARD BASIN
TREATED WASTE WATER
Q : 180T/H
PH : 6~8
CODMn : 100 mg/l
BOD5 : 50 mg/l
SS : 30 mg/l
TEMP. : 40 °C
UTILITY CENTER
SLUDGE FROM WATER TREATMENT
Q : 40 T/H
PH : 6~8
THICKENER
REGENERATION WATER FROM WATER TREATMENT
Q : AV. 16 T/H
PH : 6~8
TDS : MAX. 5000 mg/l
DEHYDRATOR
CAKE
C/W BLOW DOWN
Q : 87 T/H
PH : 7~8
SS : 20 mg/l
BOILER BLOW DOWN
Q : 2.2 T/H
PH : 9.4~11
TDS : 700 mg/l
LIVING WASTE WATER
CLEAN WASTE WATER
CLEAN WATER
ETHYLENE AND VCM PLANT PROJECT IN THAILAND
FLOWSHEET OF WASTE WATER TREATMENT
J I C A
FIG. V-32

(3) Runoff containing oil, from the ethylene plant

Oil is separated by the CPI oil separator and suspended solids are removed by coagulative sedimentation.

(4) VCM plant waste water

Suspended solids are removed by the sand filter and material influencing COD is eliminated by activated carbon adsorption.

(5) Sludge from water processing facilities

Solids and water are separated in the thickener and suspended solids are removed by the sand filter.

(6) Effluent not processed in central waste water treatment facilities

The following effluent is not to be processed in the central waste water treatment facilities and is to be sent directly to the guard basin, because no pollutants are present:

Cooling tower blow-down
Circulating water from the boiler water treatment facility
Boiler blow-down

In addition to this, living waste water is to be separately processed before being discharged.

All processed effluent and waste water is collected in the guard basin and discharged into the ocean through the sewer. All such discharge shall conform to the standards given below.

Standards for discharge from the guard basin

Quantity	180 m^3/hr	
Qualities	BOD:	50 mg/ℓ
	COD:	100 mg/ℓ
	Suspended solids:	30 mg/ℓ
	Temperature	40°C
	pH:	6 – 8

For reference, standards in use in Japan are as follows.

(A) Emission standards (national level)[1]

Pollutant	Facilities	Permissible limit
Chlorine	Electrolysis plant VCM plant	30 mg/Nm^3
Hydrochloric acid	Electrolysis VCM plant	80 mg/Nm^3
	Incinerator	700 mg/Nm^3
NO_x	Gas-fired boiler	100 ppm (for new boilers)
	Gas-fired boiler	160 ppm (for existing boilers)
Soot	Gas-fired boiler	0.20 g/Nm^3
	Incinerator	0.70 g/Nm^3

1) Air Pollution Control Law (1977).

(B) Waste water standards (national level)[2]

Pollutant	Permissible limit
pH	5.0 – 9.0
BOD	160 mg/ℓ (monthly average 120 mg/ℓ)
COD	160 mg/ℓ (monthly average 120 mg/ℓ)
Suspended solids	200 mg/ℓ (monthly average 150 mg/ℓ)
Compounds extracted by n-hexane (Mineral oil content)	5 mg/ℓ
Phenols content	5 mg/ℓ
Copper content	3 mg/ℓ
Zinc content	5 mg/ℓ
Total dissolved solid	Not regulated
Free chlorine	Not regulated
Temperature	Not regulated

2) Water Pollution Control Law (1979).

PART VI REQUIRED CAPITAL

PART VI REQUIRED CAPITAL

CHAPTER 1 REQUIRED CAPITAL

1-1 INTRODUCTION

As is stated in Part V, various technical assumptions have been made, a conceptual design has been prepared, and an implementation plan has been formulated. The results of calculation of the total capital requirement done on the basis of the foregoing, is given in Tables VI-1 and VI-2.

Basic assumptions for the calculation were:

Type of contract:	Turnkey, lump-sum contract, to be carried out by a general contractor
Procurement method:	International competitive bidding
Base prices:	Prices as of the end of 1980
Currency conversion rates used for estimations:	Local currency portion: US$1 = 20.5 Baht Foreign currency portion: Estimated in Yen and converted to dollars US$1 = ¥215
Import tax:	Assumed to be zero

Table VI–1 CAPITAL COST ESTIMATE FOR PTT ETHYLENE PROJECT
(Ethylene 230,000 T/Y)

(US$ thousand in constant 1980 Prices)

	Ethylene Plant			Tank Yard			Utilities Center			Offsite			Total		
	F.C.3)	L.C.4)	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
FOB Equipment 1)	46,092	–	46,092	7,349	–	7,349	17,907	–	17,907	7,395	–	7,395	78,743	–	78,743
License, Basic Design Detail Engineering, Procurement and Project Management	17,209	–	17,209	558	–	558	2,140	–	2,140	2,000	–	2,000	21,907	–	21,907
Transportation and Insurance 2)	6,758	1,800	8,558	3,084	823	3,907	2,349	628	2,977	1,763	470	2,233	13,954	3,721	17,675
Civil	1,604	8,907	10,511	56	316	372	498	2,758	3,256	2,679	14,905	17,584	4,837	86,886	31,723
Erection	1,954	10,744	12,698	698	3,860	4,558	1,046	5,744	6,790	488	2,582	3,070	4,186	22,930	27,116
Supervising	4,744	698	5,442	814	116	930	1,860	279	2,139	814	116	930	8,232	1,209	9,441
Plant Cost (as erected)	78,361	22,149	100,510	12,559	5,115	17,674	25,800	9,409	35,209	15,139	18,073	33,212	131,859	54,746	186,605
Land Cost													–	373	373
Pre-operation & Start-up Expenses													1,256	7,385	8,641
Interest during Construction													12,448	5,844	18,292
Total Fixed Capital													145,563	68,348	213,911
Initial Working Capital														6,150	6,150
Total Capital Investment													145,563	74,498	220,061

Notes: 1) Including spare parts and catalysts for 2 years.
2) Including inland transportation cost.
3) F.C.; Foreign Currency Portion
4) L.C.; Local currency Portion

Table VI–2 CAPITAL COST ESTIMATE FOR VCM PROJECT
(VCM 80,000 T/Y)
(Caustic Soda 51,600 T/Y)

(US$ thousand in constant 1980 prices)

	Thai VCM/Caustic Soda Project														
	VCM Plant			Electrolysis Plant			Utilities Center			Offsite			Total		
	F.C.[3]	L.C.[4]	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
FOB Equipment [1]	15,116	–	15,116	24,372	–	24,372	3,488	–	3,488	4,558	–	4,558	47,534	–	47,534
License, Basic Design Detail Engineering, Procurement and Project Management	8,047	–	8,047	5,581	–	5,581	3,023	–	3,023	3,535	–	3,535	20,186	–	20,186
Transportation and Insurance [2]	2,442	488	2,930	2,014	405	2,419	893	177	1,070	1,349	279	1,628	6,698	1,349	8,047
Civil	977	2,837	3,804	–	4,000	4,000	116	349	465	2,856	8,307	11,163	3,949	15,493	19,442
Erection	1,349	2,698	4,047	595	4,428	5,023	419	837	1,256	1,093	2,162	3,255	3,456	10,125	13,581
Supervising	4,526	544	5,070	2,572	312	2,884	1,619	195	1,814	121	19	140	8,838	1,070	9,908
Plant Cost (as erected)	32,457	6,567	39,024	35,134	9,145	44,279	9,558	1,558	11,116	13,512	10,767	24,279	90,661	28,037	118,698
Land Cost													–	366	366
Pre-operation and Start-up Expenses													1,256	5,526	6,782
Interest during Construction													6,894	2,544	9,438
Total Fixed Capital													98,811	36,473	135,284
Initial Working Capital													–	4,475	4,475
Total Capital Investment													–	4,475	4,475

Notes:
1) Including spare parts and catalysts for 2 years.
2) Including inland transportation cost.
3) F.C.; Foreign Currency Portion
4) L.C.; Local Currency Portion

1-2 REQUIRED CAPITAL

The breakdown of the total capital requirement is shown in Tables VI-1 and VI-2. In prices as of the end of 1980, the total capital requirement is as follows:

(US$ 1,000 in constant 1980 prices)

	Foreign Currency Portion	Local Currency Portion	Total Capital Required
Ethylene Plant	145,563	74,498	220,061
	(66.2%)	(33.8%)	(100%)
VCM Plant	98,811	40,948	139,759
	(79.7%)	(29.3%)	(100%)

1-3 METHOD OF ESTIMATION FOR EACH ITEM

The basic thinking concerning the method of estimation to be used for each cost item is given below.

(1) Land acquisition cost

Land for the plant site has been acquired by PTT already. The present cost of land per rail is 40,000 Baht (US$1.22 per m^2). The land needed for the VCM plant is not included in that acquired by PTT but assuming that land adjacent to the PTT ethylene plant site is acquired, it follows that it can be assumed that land acquisition cost is to be at the same rate as used for land acquisition by PTT. The areas required for the two plants, including that needed for ancillary or support facilities, is 306,000 m^2 for the ethylene plant[1)], and 300,000 m^2 for the VCM plant[2)].

(2) Process plant cost

The direct and indirect costs for construction of the ethylene and VCM process plants are as described below.

A. Equipment for industrial facilities, and materials
Industrial facilities comprise all required machinery, equipment and materials, and all spare parts and reserve materials which must be on hand at the time of start-up, in FOB prices.

1) The ethylene plant land requirement includes 146,000 m^2 for housing for ethylene plant and utilities center workers.

2) The VCM plant land requirement includes 100,000 m^2 for housing for VCM and electrolysis plant workers.

B. Engineering fee and other software costs

Software costs connected with the facilities, such as engineering fees, license fees and royalties, cost of preparation of the basic design and detail design, and cost of services related to purchases of equipment and materials, such as inspections, preparation of documents etc. are included in this category. These costs are assumed to be entirely in foreign currency.

C. Transport and insurance costs

Ocean freight, unloading, inland transportation, customs duty when applicable are included in this category. It is assumed that the materials, equipment etc. will be landed at Sattahip and transported overland to the site. Insurance includes coverage during ocean shipping and protection for the machinery and equipment, etc.

D. Civil construction costs

Civil construction costs, including the costs of geological studies, grading etc., materials and erection costs of buildings and structures and indirect costs are included in this category.

E. Erection costs

The costs of erection of imported equipment, piping, wiring, instrumentation, thermal and cooling insulation, painting and required materials are included in this category. Temporary construction costs, facilities for temporary supply of utilities, costs of construction equipment, construction site office costs etc. are included as indirect costs.

F. Construction management fee

Included in this category are the costs of dispatching inspectors and other personnel to the general contractor and makers of major equipment, their travel and per diem costs, and other costs.

(3) Utilities plant costs

This item consists of direct and indirect costs of the required utilities. Details are the same as for the process plants (see (2) above).

(4) Offsite facilities cost

Included as offsite facilities costs are the costs of a repair shop, spare parts storehouse, laboratories for analysis of materials and products, administration office buildings, employee housing, health and welfare facilities, as well as roads for the plant site, fire-fighting water mains and hydrants, gates, fences, etc.

(5) Pre-operation costs

Costs of employees, including their training, up to the start of commercial operation of the ethylene and VCM plants; consulting fees, cost of materials and utilities consumed during test operation, transportation and communication costs, various fees and charges are included in this item.

(6) Initial working capital

This item has been estimated based on the following conditions as stated below.

	Ethylene Plant	VCM Plant
Product storage:	Four days of ethylene production, with plant operating at full capacity	15 days of VCM production, with plant operating at full capacity 15 days of caustic soda production, with plant operating at full capacity
Materials storage:	Five days of ethane requirement, with plant operating at full capacity	Two months of salt requirement, with plant operating at full capacity
Accounts payable, accounts receivable:	45 days sight bills	45 days sight bills

In the above, only variable costs of production are included in accounts payable.

(7) Interest during construction

With 75% of the total capital requirement obtained by borrowing, the payment schedule has been formulated according to funds planning as described in the following chapter. Annual interest is taken to be 8%, and funds are to borrowed and repaid according to the schedule shown.

CHAPTER 2 FUNDS PLANNING

As a result of discussions with PTT, it has been decided to assume that 25% of the total required capital will be obtained as owner's equity and the remaining 75% in addition to the initial working capital requirement will be obtained by long-term borrowing. Interest during construction is included in the total capital requirement but excluded from calculation of the internal rate of return.

The source of loans has not yet been determined but for purposes of this study the general practice among international financial organizations has been taken into consideration; in accordance with that the terms and conditions are to be repayment in 10 equal annual installments after a three-year period of grace, and interest is to average 8% per annum. The schedule for receipt of the loans is assumed to be as follows:

	Ethylene Plant	VCM Plant
1982	15%	–
1983	35%	30%
1984	35%	50%
1985	15%	20%

In the event that a shortage of capital occurs during operation of the plants, it is assumed that short-term loans from domestic financial institutions will be obtained and that the annual interest rate for such loans will be 13%.

A simplified repayment schedule is included among the financial statements provided as attachments to Part XI.

PART VII FINANCIAL ANALYSIS

PART VII FINANCIAL ANALYSIS

CHAPTER 1 INTRODUCTION

This part of the study report is concerned with the production cost of ethylene and VCM, and the financial projection and financial analysis of the project, as well as the results of evaluation of the viability of the project from its financial aspects.

1–1 NATURE OF IMPLEMENTING BODY

There is a strong possibility that the ethylene project will be undertaken by PTT, and that the VCM project will be undertaken by a private firm. Therefore, it is necessary to proceed with financial analysis of each of the two projects separately. It is desirable that the ethylene plant and its derivatives plants be adjacent to one another; this is the usual arrangement with regard to ethylene plants. In accordance with the conclusion stated in Part IV, in this part of the study report it is assumed that the VCM plant is located adjacent to the ethylene plant, that ethylene is supplied to it by means of piping, and that they make use of a common utilities center.

This common utilities center is presumed to be located on part of the ethylene plant site. The investment required for the ethylene and VCM plants, and calculation of the utilities cost is done in accordance with the reasoning given below.

(1) Ethylene project

Financial analysis of the ethylene project was performed from the following two aspects.

Case-A: The investment amount is taken to be the sum of the investment costs of ethylene production facilities, tank yard and off-site facilities, with the exclusion of the investment cost of common utilities center. It is therefore considered that necessary utilities will be purchased from the common utilities center that can be treated as an independent profit center. Utilities purchase cost is calculated by multiplying the estimated utilities sale (supply) cost[1)] by required quantities.

Case-B: The investment cost of the common utilities center is added to the investment cost used in Case-A. Utilities sale cost to VCM project, etc., can be credited from ethylene production cost.

1) The operating cost of utilities facilities, plus interest and return on ivestment. The method of calculation is given at a later point. (see 3-2 in this Part)

(2) VCM project

The investment amount is taken to be the investment costs of the VCM and industrial salt electrolysis plants,[1] the tank yard and the offsite facilities, and no provision is made for a share of the common utilities center. Therefore all required utilities are to be purchased from the common utilities center or outside[2]. Utilities purchase cost is determined by multiplying the estimated utilities sale (supply) cost obtained as for Case-A for the ethylene project by the required quantities.

1–2 OTHER CONDITIONS USED FOR MAKING CALCULATIONS

Production cost figures and the financial projection used in this part of the study report have been obtained on the basis of assuming that both the ethylene and VCM projects commence commercial production in July, 1985, and that the economic life span of this project is 15 years starting from the first year of commercial operation.

These production costs and financial projection use constant 1980 prices. By "constant 1980 prices" is meant the level of actual prices which is estimated as of 1980, and the level of prices which will not change during the life of the project. The objective of the calculation is to evaluate the feasibility of the project, and uncertainty due to increases in prices is excluded.[3] The actual amount of capital which must be invested will rise in time due to increases in various prices, and therefore will be higher than the amount used here, and review of the financial situation will be necessary at the stage of project implementation.

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1) Note that the cooling tower system and electricity receiving facilities from PEA/EGAT are included herein.

2) With the exception of electric power and natural gas, all utilities are to be supplied from the common utilities center.

3) The most important objective of this feasibility study is to etermine if an ethane-base ethylene project in Thailand is feasible, or, in another perspective, to determine what ethane supply price will make the ethylene project feasible. Therefore, it would only complicate work to apply escalation rates to current costs and thereby determine prices and costs at some future date (e.g., 1985), and would not make the conclusion any more reliable.

CHAPTER 2 SALES PLAN

2–1 PRODUCTION AND SALES PLAN OF THE PRODUCTS

2–1–1 Ethylene Project

Production capacity of the ethylene project, in accordance with the conclusion of Part IV, is assumed to be 230,000 t/y. In addition to the supplying of most of the ethylene produced in this plant for LDPE and HDPE production, it will be supplied to the VCM plant which is studied here.

The production and sales plan developed on the basis of ethylene demand as in Part II and in view of the outlook for sales has been determined as follows. The ethylene stock quantity is to be 3,500 t (5 days' output at 100% utilization of capacity), which is to be produced during the first year of operation in addition to the sales volume for that year.

Ethylene production sales plan

(unit: ton)

	Ethylene		
	Production	Sales	Stock
1985	70,500	67,000	3,500
1986	142,700	142,700	3,500
1987	149,700	149,700	3,500
1988	170,600	170,600	3,500
1989	182,600	182,600	3,500
1990	189,400	189,400	3,500
1991	199,300	199,300	3,500
1992	206,600	206,600	3,500
1993	214,300	214,300	3,500
1994	230,000	230,000	3,500
1995	230,000	230,000	3,500

2–1–2 VCM Project

Production capacity of the VCM project, in accordance with the conclusion of Part IV, is to be 80,000 t/y. All VCM produced is to be shipped for use as feedstock for production of PVC. The chlorine needed to produce VCM is to be produced within the VCM project itself, by means of an industrial salt electrolysis plant. The electrolysis plant production capacity is to be 48,000 t of chlorine and 51,600 t of caustic soda. All of the chlorine is to be allocated to the VCM project, and the caustic soda is to be sold to users.

The production and sales plan for VCM, based on the expected level of VCM demand as given in Part II and in view of the sales outlook, has been determined as follows. The quantity of product as stock at the plant is to be 3,360 t of VCM and 2,167 t of caustic soda (15 days' output at 100% utilization of capacity), to be produced in addition to the quantity to be sold during the first year.

VCM and caustic soda production and sales plan

(unit: ton)

	VCM			Caustic soda		
	Production	Sales	Stock	Production	Sales	Stock
1985	32,160	28,800	3,360	20,743	18,576	2,167
1986	62,800	62,800	3,360	40,506	40,506	2,167
1987	68,400	684 00	3,360	44,118	44,118	2,167
1988	74,400	74,400	3,360	47,988	47,988	2,167
1989	80,000	80,000	3,360	51,600	51,600	2,167
1990	80,000	80,000	3,360	51,600	51,600	2,167
1991	80,000	80,000	3,360	51,600	51,600	2,167
1992	80,000	80,000	3,360	51,600	51,600	2,167
1993	80,000	80,000	3,360	51,600	51,600	2,167
1994	80,000	80,000	3,360	51,600	51,600	2,167
1995	80,000	80,000	3,360	51,600	51,600	2,167

2–2 SALES PRICES OF PRODUCTS

The anticipated sales prices of products, used as a basis for financial projection and analysis, are as follows.

2–2–1 Ethylene Project

(1) Ethylene

Ethylene produced at this plant is to be supplied to the LDPE plant now being constructed in Rayong, the HDPE plant which is now being planned, as well as the VCM project, and it had been anticipated that the ethylene feedstock for it would be imported as
project, and it had been anticipated that the ethylene feedstock for it would be imported as
liquefied ethylene. It is necessary for the price of ethylene produced by this project to be at least as low as the price of imported ethylene. Furthermore, the ethylene price must be at a level which facilitates setting of prices of LDPE, HDPE and VCM, made using this ethylene as feedstock, at levels competitive with those of imports.

Using the results of the market study (Part II), the ex-factory price as of 1980 of US$800/t[1] is used as the standard for the base-case financial projection and analysis. For sensitivity tests, the ethylene price was varied ±10% of this price.

2–2–2 VCM Project

An electrolysis plant of industrial salt as the source of chlorine would be included as a part of the VCM project and therefore caustic soda would be produced in addition to VCM.

(1) VCM

VCM produced at this plant is to be supplied to PVC plants presently in operation or to be expanded or newly constructed in the future. The VCM price in principle is not to be less than that of imported VCM. Moreover, if a single plant, which produces both the VCM to be produced by this project and PVC made from that VCM feedstock, is envisioned, then there must be conditions so that that PVC would be less costly than imported PVC.

On the basis of this line of thinking, the ex-factory price for use in the base case financial projection should be US$750/t. Sensitivity tests are performed using prices of US$700 and US$800 in addition to this.

(2) Caustic soda

Caustic soda is being produced in Thailand at the present time, but production is not adequate to satisfy demand and the amount equal to the shortfall is being imported. Reflecting this situation, domestic transactions are being made using the price of US$500/t[2] which is higher than the international market price.

Because caustic soda will be obtained as a co-product when chlorine needed for this project is made, it will be necessary to carry out a strong campaign to develop new uses so that the caustic soda can be consumed in the domestic market. In order to do this, the present domestic market price is not suitable, and it is expected that it will be necessary to reduce the price somewhat, while keeping the world market price in mind. On the basis of this thinking, for the base case financial projection, the ex-factory shipment price is set at US$350/t. For sensitivity tests, US$300 and US$400 are also used.

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1) Because this ethylene price is taken as primarily representing the price to large-scale users – polyethylene producers – even though the corporate entity involved is different, work here is done on the assumption (for the sake of convenience) that those users are integrated with this ethylene project. In the event that the profitability of the VCM project is low, to the extent that it is not attractive to private investors, demand for ethylene would be lowered by the equivalent of the VCM project's demand, and a basic assumption of the project for which this feasibility study has been undertaken would be altered. This matter is considered at Part IX in this report.

2) Converted to 100% NaOH.

CHAPTER 3 PRODUCTION COST

3–1 RAW MATERIALS PRICES

3–1–1 Ethylene Project

(1) Ethane price

The price of ethane to be supplied from the PTT gas processing plant has not yet been determined. It is conceivable that the price may be set as a fuel equivalent price, at which ethane could not be effectively used as feedstock for ethylene production. The lowest price which may be used for ethane, as a fuel equivalent price, would be US$4.218/MMBtu, as the price equivalent in terms of calories to the US$25.5/bbl price of heavy oil. For ethane, it is estimated that this would mean a price of US$190/t.[1]

On the basis of the results of the comparative studies of alternatives for the ethylene plant (Part IV, Chapter 2), the ethane supply price for this project is provisionally set as US$350/ton[2], and in the sensitivity tests, this figure is suitably varied.

3–1–2 VCM Project

(1) Ethylene price

Ethylene consumed in the VCM project is to be supplied by piping from the ethylene plant, located on an adjacent site. The price of ethylene at its entrance to the VCM plant is the ex-ethylene-plant price. Therefore, for the base case the price of US$800/t is used but in consideration of the economics of operation of the VCM project, study is also done of the effects of using the alternative price of US$700/t.

(2) Salt price

The salt to be used as the source of chlorine is to be either rock salt mined in Thailand or marine salt. Regarding rock salt, an ASEAN rock salt-soda ash project is under study, but the conclusion regarding its future has not been announced. Therefore, on the basis of the price of marine salt supplied to existing electrolysis plants and taking into consideration the cost of transporting the salt to the plant site, the price is set at 450 Baht/t (US$22/t).

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1) Because the low heating value (LHV) of ethane is 11,349.6 Kcal/kg, ($4.218) × (11,349.6) $(10^{-3})/(0.252)$ = US$190/t ethane.

2) If ethylene is sold at $800/T, this ethane price is judged to assure the feasibility of this project, on the basis of the discussion in Part IV.

3–2 UTILITIES SUPPLY PRICES

3–2–1 Method of Determining Utilities Prices

As is mentioned above, there is a strong likelihood that the ethylene project and the VCM project (the latter including an electrolysis plant for production of chlorine) will be operated by two different entities. Nevertheless, in order to minimize the overall cost of facilities, and reduce operating costs, it is desirable to avoid duplication of investment in facilities, and to centralize the production and supply of utilities wherever it is possible to do so. For purposes of this feasibility study, the situation in petrochemical complexes in other countries has been given full consideration with the result that the approach adopted here is to assume that the facilities for production and supply of the utilities required to operate the individual plants are to be combined as a common utilities center, the management of which is to be undertaken as a part of the ethylene project[1].

It is, therefore, necessary to calculate utilities supply costs in order to independently evaluate profitability of each one of the projects. Table VII-1 indicates utilities balance and requirements for the petrochemical complex which have been prepared based upon the result of the technical study described in Part V.

Table VII-2 shows breakdown figures[2] of the investment cost required for the utilities center (shown in Table VI-1) to be integrated into the ethylene plant. It also shows labor requirements[3] broken down into each of the utilities generation facilities included in the utilities center. Prices of all the utilities[4] other than those supplied from outside, that is, raw water and electric power, have been calculated[5] on the basis of the data mentioned above. A reasonable rate of return on investment in the utilities center should be included in the prices.

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1) This is deemed to be the most suitable arrangement in view of the fact that most of the total utilities requirement is for use by the ethylene plant, and out of consideration of making efficient use of the start-up boiler of the ethylene plant. Furthermore, petrochemical projects in developing countries are frequently structured so that the ethylene plant is managed by the government, and downstream projects are undertaken by companies in the private sector, and in such cases generally utilities are supplied to the downstream projects together with ethylene.

2) Pre-operation costs were determined in proportion to the cost of each utility factility.

3) Of the personnel shown in Table V-25, those workers other than the ones directly engaged in operation of the ethylene plant and utilities center were allocated to the ethylene plant and utilities center according to the following method.

    Administrative workers. allocated according to the ratio of ethylene plant operators to utilities plant operators.

    Maintenance and technical workers· allocated according to construction cost of the ethylene plant and utilities plant

    As a result of this, of the total of 344 workers, 247 are considered to work in relation to ethylene and 97 in relation to utilities. These 97 utilities workers are allocated to each utility facility according to the facility construction cost in Table VII-2, and are presented as the labor requirement for each utility facility.

4) Oxygen supplied to the oxychlorination reaction in the VCM plant is also included in this category.

5) Cost required for waste water treatment carried out in the utilities center has also been calculated :

Table VII–1 BALANCE AND REQUIREMENTS FOR RAW MATERIALS, PRODUCTS AND UTILITIES (ETHYLENE 230,000 T/Y)

Requirements of Materials and Utilities, etc. / Facilities / Companies	Unit	Total Complex: PTT: Ethylene Plant	PTT: Utilities Center: Raw Water Clarifier & Sand Filter	Demineralizer	Polisher	Deaerator & BFW Pumps and Drives	Cooling Water System	Potable Water	Steam and Power Generation	Instrument & Plant Air Generation	Air Separation	Utilities Center Sub-Total	PTT Sub-Total	Outside PTT: Thai VCM Co.: VCM Plant	Electrolysis Plant	Thai VCM Sub-Total	HDPE Plant	Sub-Total	Total (Supply from Outside)	Remarks
Ethylene	(T/H)	△28 75											△28.75	4.75		4.75			△24.0	for Sale
VCM	(T/H)													△10.0		△10.0		△10.0	△10 0	for Sale
Caustic Soda	(T/H)														△6.45	△6.45		△6.45	△6.45	for Sale
Ethane	(T/H)	35.87											35.87						35.87	from LPG plant
Salt	(T/H)														11.4	11.4		11.4	11.4	
Chlorine	(T/H)													6.0	△6.0	-		-	-	
Hydrochloric Acid	(T/H)													△0.9	0.9	-		-	-	
Fuel Gas	(MMBTU/H)	44.84							207.9			207.9	252.74	43.65	△19.84	23.81		23.81	276.55	from LPG plant
Raw Water	(T/H)		474									474	474						474	from Dok Krai reservoir
Power	(KW)	1,435	271	104	45		528	9	△3,152		760	△1,435	-	2,367	17,280	19,647	5,300	24,947	24,947	from EGAT
Steam, 42[K]	(T/H)	13.9				3.52	12.97		△42.73	3.64		△22.6	△8.7				8.7	8.7	-	
Steam, 15[K]	(T/H)								△8.6			△8.6	△8.6	6.2	2.4	8.6		8 6	-	
Steam, 2[K]	(T/H)					14.99	△12.97		△2.88	△3.64		△4.5	△4.5	4.5		4.5		4.5	-	
Filtered Water	(T/H)		△436.4	57.4			230	10				△139	△139	80	14	94	45	139	-	
Demineralized Water	(T/H)			△45.92	36.12							△9.8	△9.8		9.8	9.8		9.8	-	
Condensate	(T/H)	△127.4			127.4							127.4	-						-	
Polished Water	(T/H)				161.42	161.42						-	-						-	
Boiler Feed Water	(T/H)	124				179.83			55.83			△124	-						-	
Potable Water	(T/H)	5						△10				△10	△5	2.5	2 5	5		5	-	
Cooling Water	(T/H)	6,900					△7,400		350	50	100	△6,900	-						-	
Instrument & Plant Air	(Nm^3/H)	1,168	20	20	20	20	20		50	△2,500	140	△2,210	△1,042	450	592	1,042		1,042	-	
Oxygen	(Nm^3/H)										△1,050	△1,050	△1,050	1,050		1,050		1,050	-	
Inert Gas (Nitrogen)	(Nm^3/H)	500									△1,130	△1,130	△630	200	20	220		220	△410	Purge
Catalyst & Chemicals	($/Hour)	143.7	8.4	11.6	2 3		34.5					56.8	200.5	11.2	147.6	158.8		158.8	359.3	
Erected Plant Cost (Thousand $ in 1980 constant price)													186,605			118,698			305,303	
Man Power Requirement													344			294			638	

Note: 1) △ = Generation
2) 8,000 Hours/Year Base

Table VII–2 BREAKDOWN FIGURES OF CAPITAL COST AND LABOR REQUIREMENT FOR UTILITIES CENTER (PTT)

(US$ thousand in constant 1980 prices)

	Utilities Facilities	Plant Cost (as erected)	Pre-operation & Start-up Expenses	Interest During Construction	Total	Labor Requirement
1.	Clarifier Sandfilter	3,182	151	312	3,645	8.8
2.	Demineralizer	1,481	71	145	1,697	4.1
3.	Polisher	1,558	73	153	1,784	4.3
4.	Deaerator & BFW Pumps/Drives	549	26	54	629	1.5
5.	Potable Water	110	5	11	126	0.3
6.	Cooling Water System	3,737	178	366	4,281	10.3
7.	Instrument & Plant Air Generation	1,127	53	110	1,290	3.1
8.	Air Separation	5,745	271	562	6,578	15.8
9.	Steam & Power Generation	11,763	556	1,151	13,470	32.4
10.	Waste Water Treatment	3,511	166	344	4,021	9.7
	(Sub-total)	(32,763)	(1,550)	(3,208)	(37,521)	(90.3)
11.	Main Substation	2,446	115	240	2,801	6.7
	Total	35,209	1,665	3,448	40,322	97

Basis for the calculation of utilities prices, and its result are shown in the following sections.

3–2–2 Basis for Calculation of Utilities Prices

(1) Price of utilities bought from outside the complex

Industrial water	:	US$0.098/t (Baht 2/t)
Fuel gas	:	US$4.218/MMBtu (low heat value)
Electricity	:	US$0.054/kwh (Baht 1.1/kwh)[1]

(2) Basis for calculation of utilities prices

Depreciation	:	Straight-line, 10 years, no residual value.
Labor cost	:	US$2,700/person/year x number of persons.
Overheads	:	100% of labor cost.
Insurance and tax	:	1.5% of each plant cost per year
Maintenance cost	:	2% of each plant cost per year.
Interest	:	Assuming that 75% of the capital investment is obtained by borrowing, and that the interest rate is 8%. Therefore the average annual interest is 8% x 0.75 = 6% a year.
Chemicals	:	As indicated in Table VII-1.
Utilities	:	Regarding the utilities supply which must be acquired from outside the complex, the price given in the preceding subsection of this section 3-2-2 is multiplied by the required quantity. Regarding other utilities, the rates determined here are multiplied by the required quantity.
Return on investment in utilities facilities:		Annually, 14% of the amount invested in the utilities center.

1) Therefore the price of power generated in the utilities center is taken to be the same as this price.

3–2–3 Determination of Utilities Prices

The prices of utilities supply, calculated in accordance with the above approach is indicated in Table VII-3. The price of utilities supply from the utilities center to the VCM plant and to the ethylene plant (in the case of the Case A method of evaluation given above) is to be as shown therein.

3–3 DEPRECIATION AND AMORTIZATION

There are no specific regulations concerning depreciation and amortization in Thailand; the usual internationally accepted practice is assumed to be followed and it puts the economic life of chemical plants like this one at 10 years. Straight-line depreciation is used and residual value is assumed to be zero. Land cost and working capital are not depreciated.

3–4 LABOR AND OVERHEAD COSTS

Direct labor costs have been calculated on the basis of wages information provided by PTT and are expressed as average pay per employee. Using the average 1980 personnel cost of US$150/month (about Baht 3,000/month) and adding to it six months' pay as bonuses, the average annual personnel cost for one employee is US$2,700. Overhead is calculated as 100% of the personnel cost.

3–5 REPAIR AND MAINTENANCE COST, AND INSURANCE AND FIXED ASSET TAX

Annual repair and maintenance cost is taken to be equivalent to 3% of the plant cost. Insurance and fixed asset tax are taken to be equivalent to 1.5% of the plant cost.

Table VII–3 UTILITIES PRICE (FROM PTT UTILITIES CENTER)

Filtered Water	:	\$0.52/T
Demineralized Water [1]	:	\$2.64/T
Polished Water	:	\$3.18/T
Boiler Feed Water	:	\$4.95/T
Potable Water	:	\$1.13/T
Cooling Water (Recirculation)	:	\$0.077/T
Steam [2] 42K	:	\$31.7/T
15K	:	\$22.19/T
2K	:	\$15.85/T
Instrument & Plant Air	:	\$0.047/Nm^3
Oxygen & Nitrogen	:	\$0.19/Nm^3
Fuel Gas	:	\$4.218/MMBtu [3]
Raw Water	:	\$0.098/T (2 Baht/T) [3]
Electric Power	:	\$0.054/KWH (1.1 Baht/KWH) [4]
Waste Water Treatment Cost	:	\$1,382,000/Year

Notes: 1) Regarding steam condensate from the ethylene plant, the same evaluation as used for demineralized water.

2) Because it is thought that the price of steam at different pressures is comparable to the effective energy with 42 k steam as 1.0, 15 k steam is 0.7 and 2 k steam is 0.5.

3) Source: PTT.

4) Soruce: EGAT/PEA.

3–6 SALES AND GENERAL ADMINISTRATIVE COSTS

The cost incurred in selling the products as well as general administrative costs such as related to head office administrative costs are taken to be the equivalent of 2% of exfactory production cost.

3–7 CORPORATE TAX

PTT is a governmental corporation, and where determined by law is treated in different manner to ordinary private corporations regarding corporate tax, import duty, etc. As a result of discussions with PTT officials, it was indicated that for purposes of financial evaluation of this project, corporate tax, business tax as well as import duties could be assumed to be waived. This waiver extends to the ethylene project and the VCM project.

3–8 ETHYLENE PRODUCTION COST

The cost of producing ethylene is shown in Table VII-4 (Case-A) and in Table VII-5 (Case-B).

From the results of the above, it was determined that the share of the ethane cost in the ethylene cost in the ethylene production cost is about 60∿70%,[1] and that of fixed costs is about 30∿35%.

In Fig. VII-1 is shown in the manner whereby change in the ethane price as well as the ethylene plant cost causes change in the ethylene production cost.[2] Whereas the change in the ethane price has the same consequences in all instances, it is the plant cost in particular which has a strong influence on ethylene production cost, and its influence gradually declines in keeping with subsequent improvement of the rate of utilization of capacity.

1) Of course this is directly influenced by the supply price for feedstock ethane. If the ethane price is higher than US$350/t, this share becomes higher, whereas if it is lower than that, the share becomes lower. There also would be some difference depending on how the scope of cost evaluation is set (e.g., Case-A and Case-B) and which year after the start of production is taken as the base (i.e., there is a difference in the rate of utilization of capacity).

2) For reference, sensitivity tests were conducted for ethylene production cost at three points in time: 1986, 1990 and 1994.

Table VII–4 ETHYLENE PRODUCTION COST (CASE–A)

	1986: 142,700 t/y		1990: 189,400 t/y		1994: 230,000 t/y	
	Production Cost		Production Cost		Production Cost	
	$/t	%	$/t	%	$/t	%
Ethane	436.7	56.3	436.7	63.2	436.7	68.2
Cat. & Chem.	5.0	8.7	5.0	9.7	5.0	10.5
Fuel Gas	6.6		6.6		6.6	
Power	2.7		2.7		2.7	
Steam	15.3		15.3		15.3	
BFW	21.4		21.4		21.4	
Condensate (Credit)	–11.7		–11.7		–11.7	
Cooling Water	18.5		18.5		18.5	
Inert Gas	3.3		3.3		3.3	
Instrument & Plant Air	1.9		1.9		1.9	
Cost for Waste Water Treatment, etc.	4.4		4.4		4.4	
Variable Cost (Sub-Total)	504.0	65.0	504.0	72.9	504.0	78.7
Labor	4.8	7.5	3.6	6.4	3.0	5.7
Plant Overhead	4.8		3.6		3.0	
Maintenance	32.3		24.4		20.1	
Insurance, etc.	16.2		12.2		10.0	
Depreciation	123.3	15.9	92.9	13.4	76.5	11.9
Fixed Cost (Sub-Total)	181.4	23.4	136.7	19.8	112.6	17.6
Ex-Factory Production Cost	685.4	88.4	640.7	92.7	616.6	96.3
Head Office Expenses & Interest Charges	89.7	11.6	50.1	7.3	23.8	3.7
Production Cost, Total	775.1	100.0	690.8	100.0	640.4	100.0

Note: The percentages 8.7, 9.7 and 10.5 are bracketed totals for Cat. & Chem. through Cost for Waste Water Treatment, etc.; 7.5, 6.4 and 5.7 are bracketed totals for Labor through Insurance, etc.

Table VII–5 BREAKDOWN OF ETHYLENE PRODUCTION COST (CASE–B)

	1986: 142,700 t/y		1990: 189,400 t/y		1994: 230,000 t/y	
	Production Cost		Production Cost		Production Cost	
	$/t	%	$/t	%	$/t	%
Ethane	436.7	56.8	436.7	65.5	436.7	71.5
Cat. & Chem. Fuel Raw Water Sales & Utilities (Credit)	5.0	0.7	6.3	0.9	11.4	0.8
Viable Cost (Sub-Total)	441.7	57.5	443.0	66.4	448.1	73.3
Labor Cost	6.5	9.3	4.9	8.0	4.0	7.4
Plant Overhead	6.5		4.9		4.0	
Maintenance	39.1		29.6		24.3	
Insurance, etc.	19.6		14.8		12.2	
Depreciation	149.5	19.5	112.7	16.9	92.7	15.2
Fixed Cost (Sub-Total)	221.2	28.8	166.9	24.9	137.2	22.6
Ex-factory Production Cost	662.9	86.3	609.9	91.3	585.3	95.9
Head Office Expenses and Interest Charges	104.8	13.7	57.1	8.7	25.5	4.1
Production Cost, Total	767.7	100.0	667.0	100.0	610.8	100.0

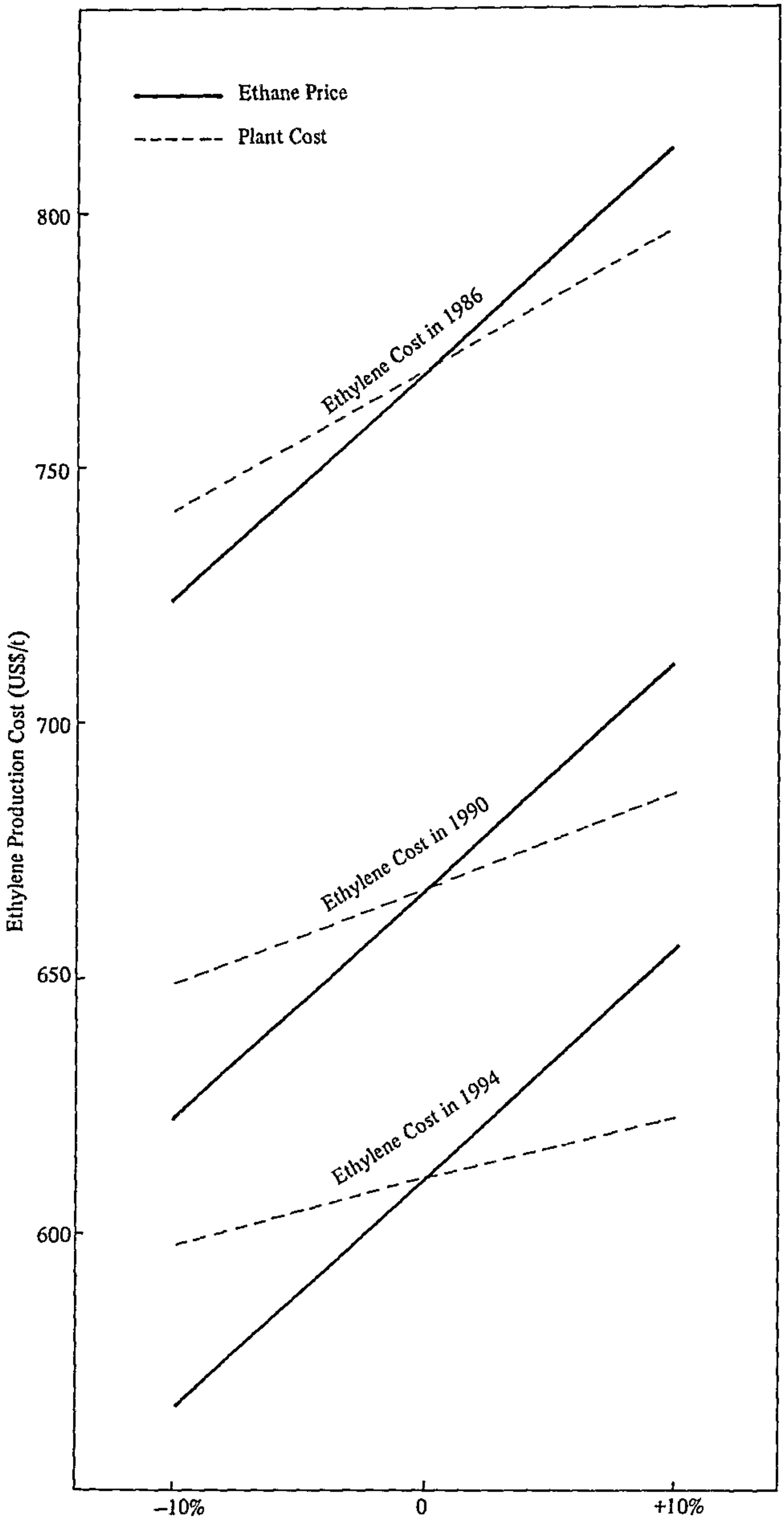

Fig. VII–1 SENSITIVITY ANALYSIS OF ETHYLENE PRODUCTION COST

3–9 PRODUCTION COST OF VCM AND CAUSTIC SODA

The production cost of VCM and caustic soda is shown in Table VII-6. Because the VCM plant project includes an electrolysis plant as the source of supply of chlorine, information here combines VCM and caustic soda obtained as a co-product of electrolysis.[1)] The shares in production cost of ethylene and electric power are about 40% and 10% respectively. Fixed costs account for about 30%.

In Fig. VII-2, the manner whereby change in ethylene price, electric power price, and plant cost cause change in the production cost of VCM and caustic soda. As may be surmised from the cost break-down, the impact of the supply price of ethylene is great. It must be given particular consideration that the influence on unit production cost of depreciation which accounts for two-thirds of the fixed cost, and power cost, is strong. The cost of power, for chemical industry use at the present time, is set at the supply price of 1.1 Baht/KWH, from which it can be seen that the most important factor which can make the project viable is the cost of power supplied to the electrolysis plant.

1) If the entire quantity of chlorine from the electrolysis plant is supplied for VCM production, for each ton of VCM, 0.645 t of caustic soda will be obtained. The cost shown here is for one ton of VCM and 0.645 t of caustic soda.

Table VII–6 BREAKDOWN OF VCM AND CAUSTIC SODA PRODUCTION COST

Production	1986		1994	
VCM	62,800 t/y		80,000 t/y	
Caustic Soda	40,506 t/y		51,600 t/y	
Breakdown	US$/T	%	US$/T	%
Salt	25			
Ethylene	380	34		41
Oxygen	20			
Chemicals	16			
Raw Materials Cost	(441)	(40)	(441)	(48)
Power	106	10		11
Other Utilities	53			
Waste Water Treatment	5			
Utilities Cost	(164)	(15)	(164)	(18)
Variable Cost (Sub-total)	605	55	605	66
Depreciation	215	19	169	18
Labor	13		10	
Maintenance	57		45	
Electrode and Iron Exchange Membrane	19	12	15	11
Insurance, etc.	28		22	
Plant Overhead	13		10	
Fixed Cost (Sub-total)	345	31	271	29
Ex-factory Production Cost	950	86	876	95
Head Office Expenses and Interest Charges	153	14	46	5
Production Cost, Total	1,103	100	922	100

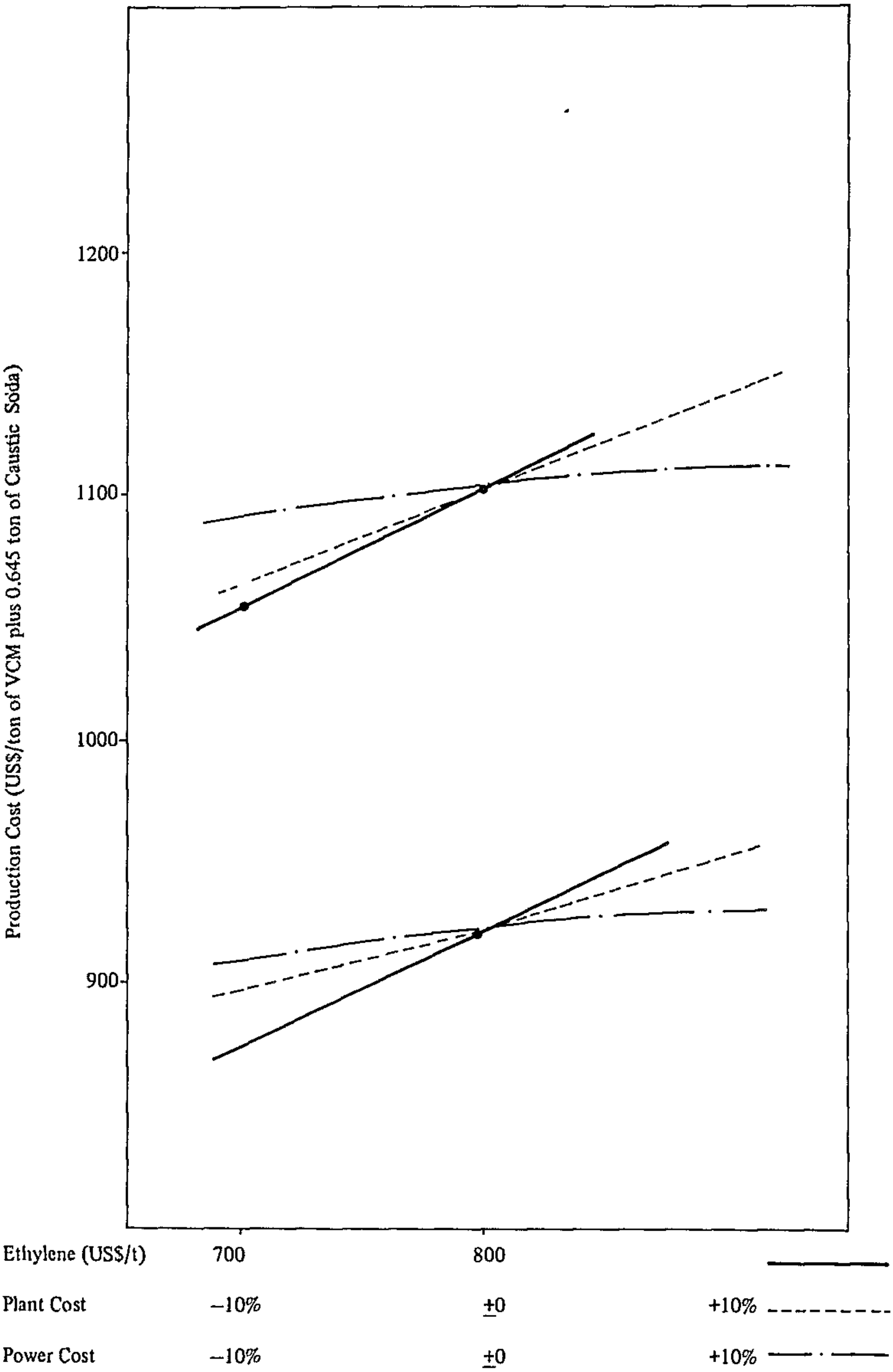

Fig. VII–2 SENSITIVITY TEST ON VCM AND CAUSTIC SODA PRODUCTION COST

CHAPTER 4 FINANCIAL ANALYSIS

4–1 ASSUMPTIONS

The assumptions given through the preceding chapter for purposes of financial analysis are as follows.

	Ethylene project	VCM project
Project life span	15 years	Same as at left
Equity/loan ratio	25/75	Same as at left
Interest		
Long-term debt	8% per annum	Same as at left
Short-term debt	13% per annum	Same as at left
Terms of repayment	13 years (incl. 3 years' grace); Equal semi-annual payments of principal.	
Product sales price	Ethylene, US$800/t	VCM, US$750/t Caustic soda, US$350/t
Raw materials price	Ethane, US$350/t	Ethylene, US$800/t Salt, US$22/t

Production quantity

	Ethylene	VCM	Caustic Soda
1985 (half-year operation)	70,500 tons	32,160 tons	20,743 tons
1986	142,700	62,180	40,566
1987	149,700	68,400	44,118
1988	170,600	74,400	47,988
1989	182,600	80,000	51,600
1990	189,400	- ditto -	- ditto -
1991	199,300	- ditto -	- ditto -
1992	206,600	- ditto -	- ditto -
1993	214,300	- ditto -	- ditto -
1994 and after	230,000	- ditto -	- ditto -

4–2 RESULTS OF FINANCIAL ANALYSIS

4–2–1 Ethylene Project

(1) Financial projections

Financial analysis of the ethylene plant project was carried out on the basis of the foregoing assumptions. The results are provided as an attachment to this part.[1] This attachment includes, in addition to financial statements such as income statements, fund flow statements, balance sheet, etc., production cost statements, the calculation of the financial internal rate of return (FIRR),[2] profitability of the project, as well as financial indicators.

(2) Financial evaluations

According to the results of the financial analysis, the profitability of the project, and its financial position, are as follows.

(a) Financial internal rate of return (FIRR)

The rate of return on investment in this project is evaluated in terms of the internal rate of return. The internal rate of return as determined by financial analysis is 19.6%. Therefore, it is judged that the project is feasible. Further, from the income statement, balance sheet, funds flow statements as well as various financial indicators shown in the attachment, it is evident that this project is, without a doubt, financially viable.

Influence imparted to the internal rate of return by change from the assumed values of key factors such as ethylene sales price, ethane supply price, and ethylene plant cost, is shown in Fig. VII-3. According to this figure, if the following adverse conditions come to exist, the downward-revised IRR, and number of percentage points drop from 19.6%, would be as shown.

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1) For the evaluation of the ethylene project from two perspectives (Case-A and Case-B) as explained in Chapter 1 of this part, refer to attachments VII-1 and VII-2.

2) Case-A and Case-B yield the same results. Therefore either one may be used to evaluate the project. In the following, Case B is used.

	IRR	Decrease of IRR
When the ethylene plant cost is increased 10%	17.6%	(2.0%)
When feedstock ethane is increased 10% in price	16.7%	(2.9%)
When ethylene sales price is decreased 10%	14.5%	(5.1%)
When the ethylene plant cost is increased 10% and the ethane price is increased 10% at the same time	14.6%	(5.0%)

Thus, even in the face of these adverse changes, the project is still feasible. It is thought to be unlikely that a combination of two changes such as these (e.g., the fourth of the above instances) will occur simultaneously. In particular, it is not possible for an increase in the ethane supply price and a decrease in the ethylene sales price to occur at the same time, so that even if the most pessimistic outlook is realized, the project will still be feasible.

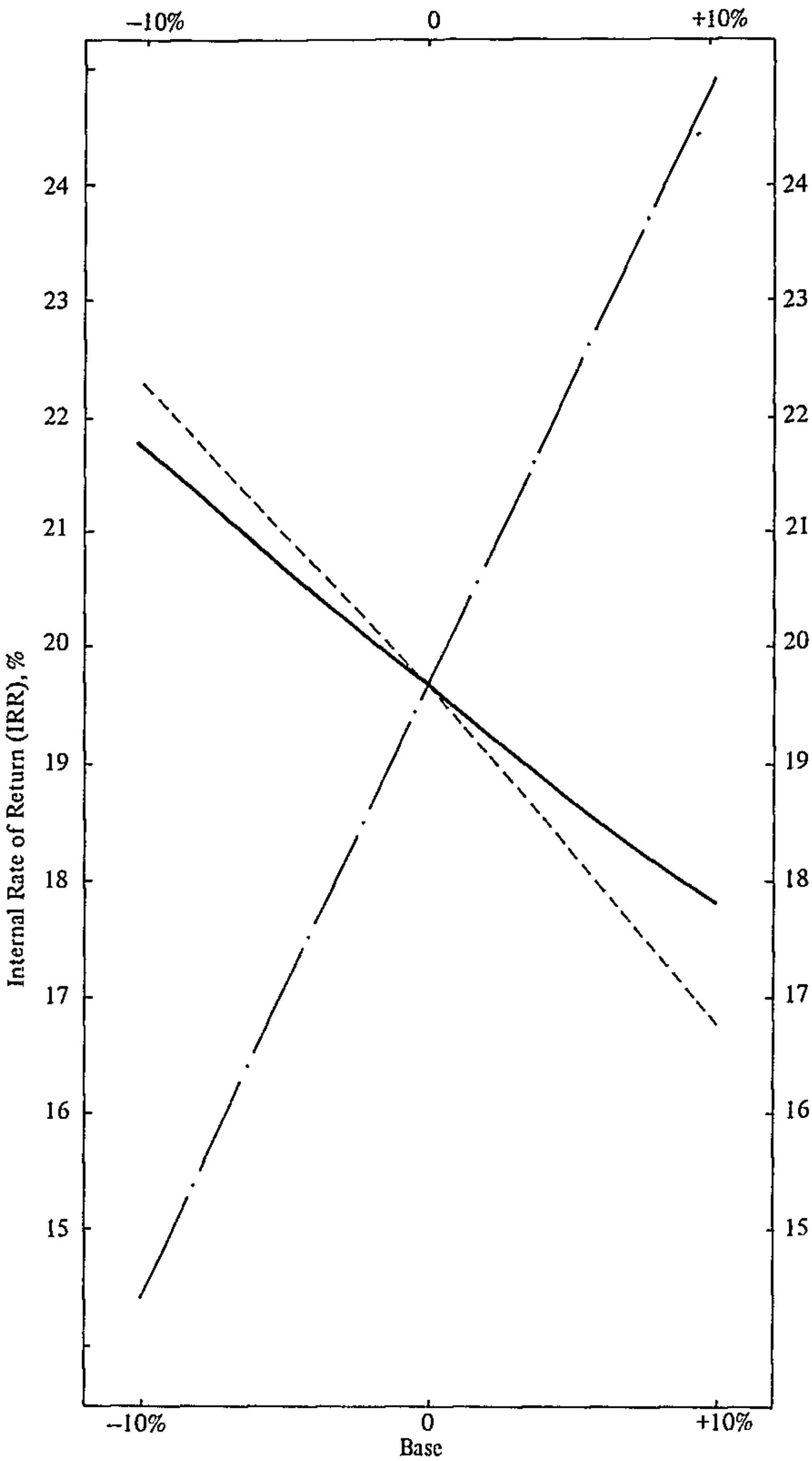
(b) Profitability

According to the income statement provided in the Attachment, profits would be obtained from the first year of operation, 1985, and would increase year by year thereafter. The ratio of profits to paid-up capital, as a 15-year average, is 68.5%, which is high enough to justify the investment decision. Further, from the viewpoint (offered by PTT) that the entire profit from this undertaking is revenue for the government, the contribution this project can make to the financial condition of the nation is substantial, and provides additional justification for the project.

(c) Financial position and debt repayment ability

As shown by the funds flow statement included in the attachment, there is no time after the start of plant operation when there will be a shortage of capital, and therefore no need exists for short-term borrowing. Further, as shown in the table of financial indicators, the debt service ratio is high, at 1.6 as minimum, and averages 3.37 over the entire repayment period, so that this project is characterized by adequate debt repayment ability. From all aspects, thus, the project is judged to be financially viable.

From the above results, this ethylene project is adequately profitable to justify the investment in it, and is financially viable.



Selling Price of Ethylene: $800/t
Price of Ethane: $350/t
Ethylene Plant Cost: $186,605,000
(at constant 1980 prices)

Fig. VII-3 RESULT OF SENSITIVITY ANALYSIS FOR PTT ETHYLENE PROJECT (CASE—B)

4–2–2 VCM Project

The results of financial analysis of the VCM project are provided as Attachment VII-3. Study of profitability and financial evaluation of the project are based on the statements in this attachment.

(1) Financial internal rate of return, and profitability

The profit earned on investment in the VCM plant project is evaluated by use of the internal rate of return, which is 10.1% according to the results of financial analysis. This is a low rate for the project to be judged to be feasible. Moreover, regarding profitability, according to the income statement, there would be a loss in each of the first five years of operation, and profits would be recorded only from the sixth year on and it would not be until 1993, the ninth year of operation, that the cumulative loss would be eliminated. Over the entire 15 years, the average ratio of profit to paid-up capital is 14.2%, which is not very high.

(2) Financial position and debt repayment ability

From the funds flow sttatement and other financial statements in Attachment VII-3, there would be shortages of funds for the first four years of operation, requiring short-term borrowing. The project does possess, however, the capability to repay the initial loan, though these calculations do not indicate any dividend payments.

From the results noted above, it may be said that the anticipated profit on investment in this project is very low, and from a financial viewpoint there is some difficulty in justifying such investment.

(3) Analysis of sensitivity to change of key economic factors

Influence imparted on the internal rate of return by change from the assumed values of key factors such as ethylene supply price, VCM and caustic soda sales price, and VCM plant construction cost is shown in Fig. VII-4. If these factors are modified in the following favorable way, the internal rate of return rises to 12∿13%, and this project approaches the stage of being feasible.

	IRR	Increase of IRR
When the ethylene supply price is US$700/t	13.1%	(3.0%)
When the VCM sales price is US$800/t	13.1%	(3.0%)
When the caustic soda sales price is US$400/t	12.1%	(2.0%)
When the plant cost is reduced 10%	12.2%	(2.1%)

Thus, if ethylene can be supplied at US$700/t, and in addition the organization implementing this project is able to reduce the plant construction cost 10%, the internal rate of return for this project can be improved to 15% or more. Of course, if these factors change adversely, the profitability of the project would suffer and there would be a loss of financial viability.

The sensitivity tests reported above represent the results of separately varying factors influencing the base case; in Fig. VII-5, however, the results are shown for simultaneously varying the VCM and caustic soda sales prices. From this figure, the conditions required in order to attain an IRR of 15%, in terms of the relationship or combination of product sales price and feedstock supply price, are as follows.

With ethylene price US$800/t:	VCM sales price, $800/t; caustic soda sales price, $400/t
With ethylene price US$700/t:	VCM sales price, $780/t; caustic soda sales price, $380/t

However, in any case the profitability of the VCM plant project is low, making the project unattractive to private investors. The entire financial analysis of the ethylene plant project, as presented in this part, is based on the assumption that the VCM plant project too will be included. Therefore, if the VCM plant were to be excluded, it would be necessary to once again study the feasibility of the ethylene project. This subject is discussed in Part IX, where a solution to the problem is proposed.

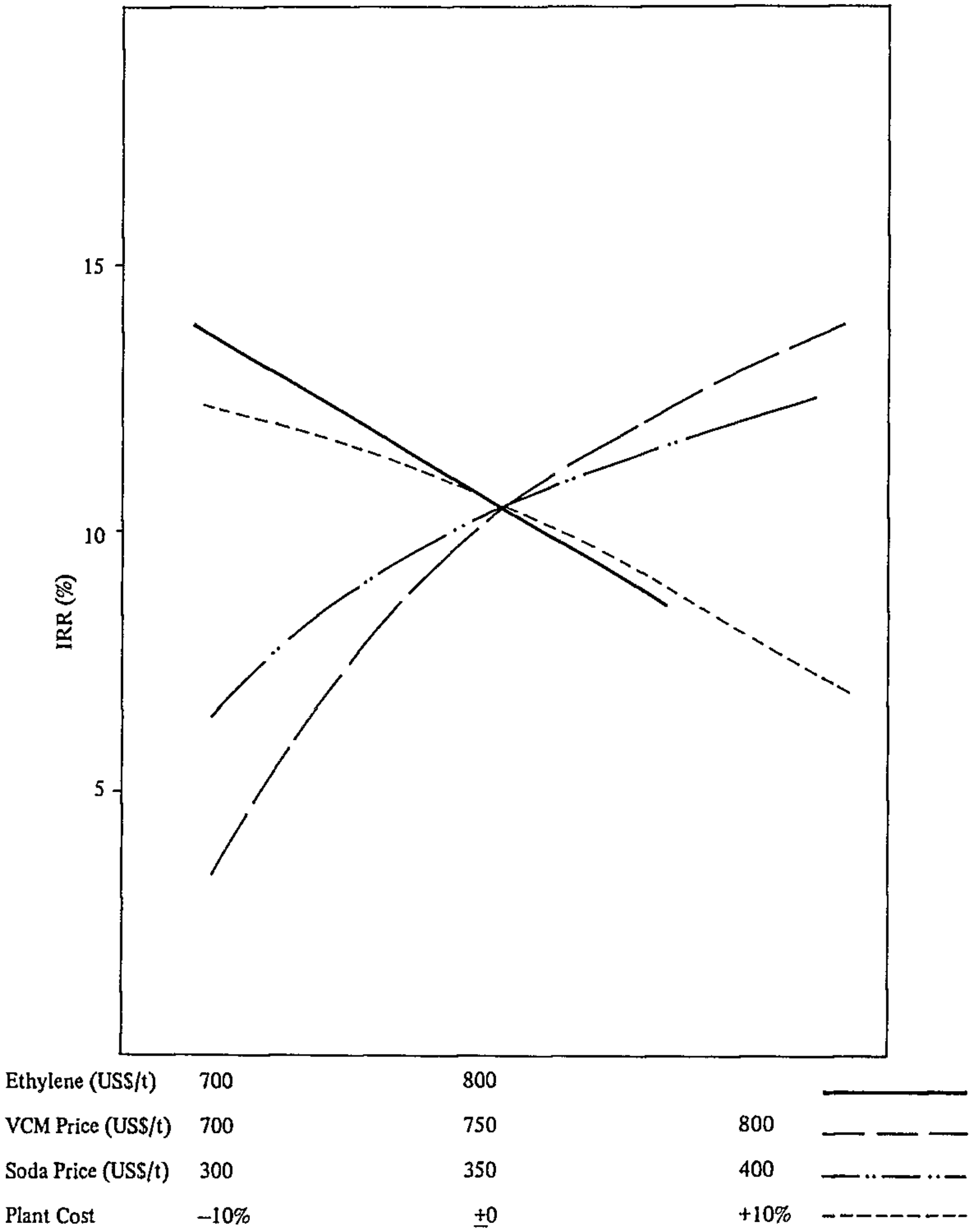


Fig. VII–4 SENSITIVITY TEST ON IRR OF VCM PLANT PROJECT

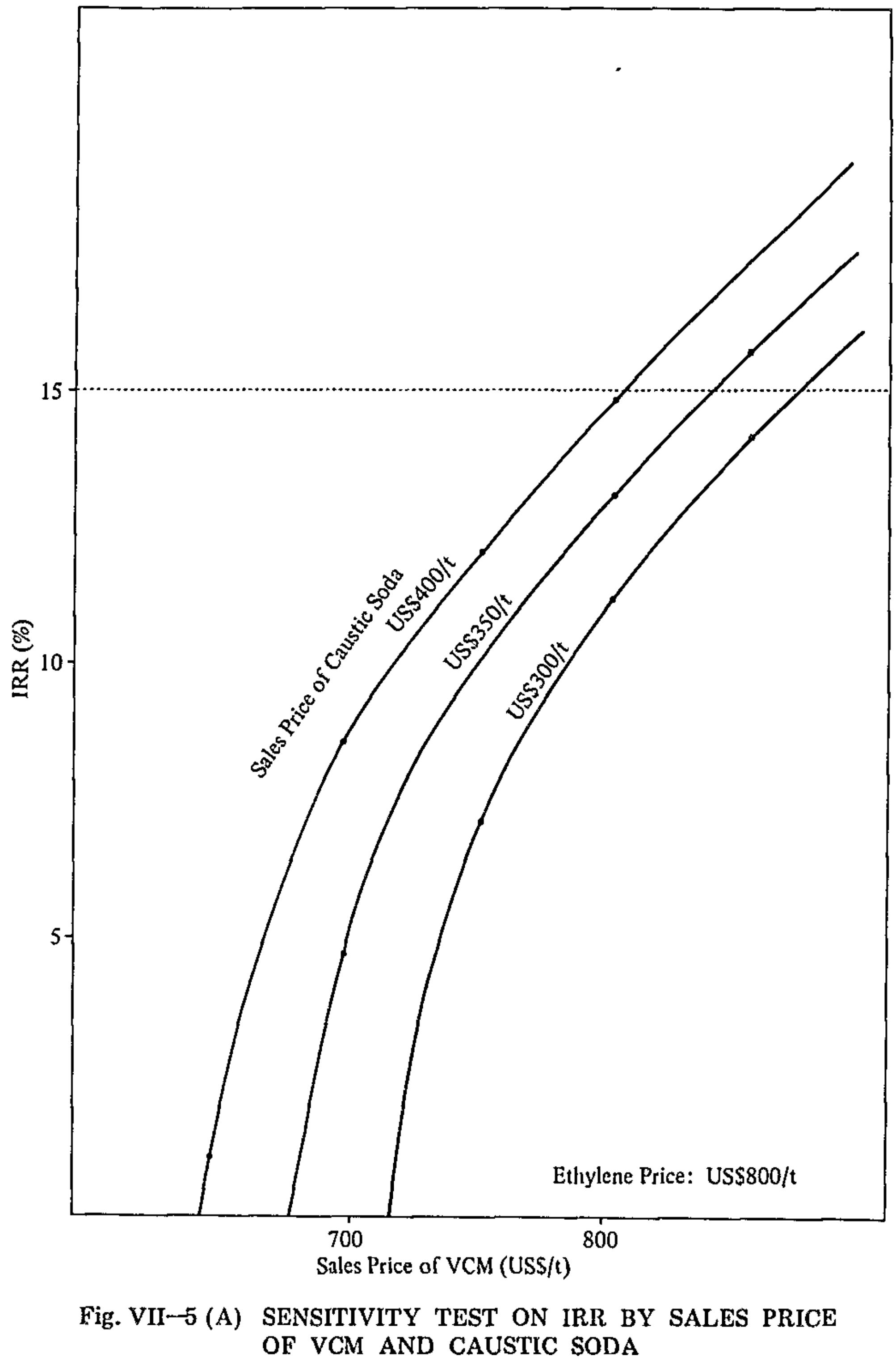


Fig. VII–5 (A) SENSITIVITY TEST ON IRR BY SALES PRICE OF VCM AND CAUSTIC SODA

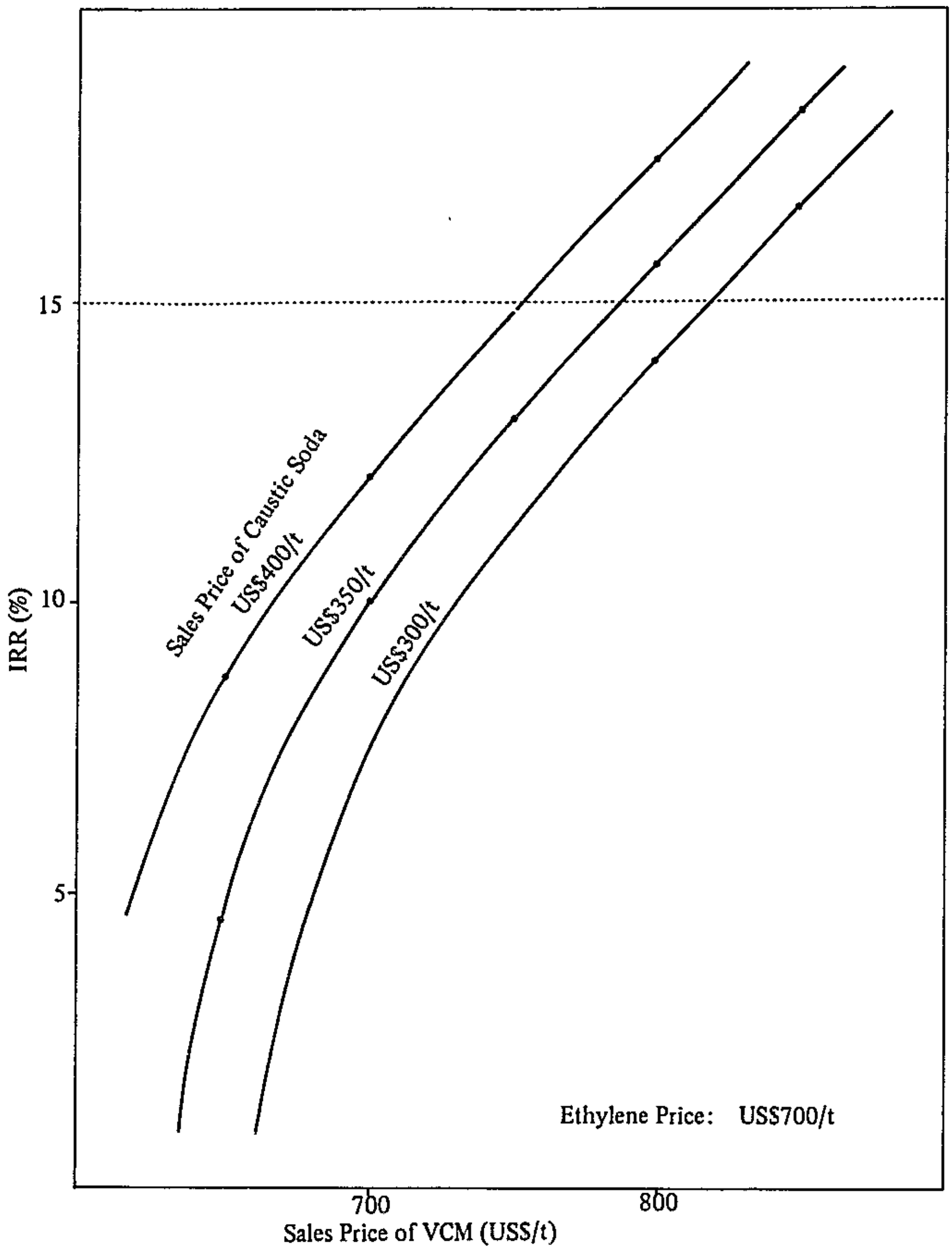


Fig. VII—5 (B) SENSITIVITY TEST ON IRR BY SALES PRICE OF VCM AND CAUSTIC SODA

ATTACHMENT VII–1

FINANCIAL STATEMENTS FOR THE ETHYLENE PROJECT

(Case–A Evaluation Method)

IRR Calculation

Profitability and Financial Indicators

Production Cost Statements

Note:	Ethylene Sales Price	:	$800/t
	Feedstock Ethane Price	:	$350/t

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***
IRR CALCULATION ON TOTAL INVESTMENT
(CASE-A : UTILITIES CENTER IS SEPARATED) (US$ 1000)

YEAR	TOTAL INVESTMENT	PROFIT BEFORE TAX	DEPRECIATN	INTEREST ON L-T DEBT	RETURN BEFORE TAX	DISCOUNT FACTOR	(BEFORE TAX) PRESENT VALUE INVEST.	(BEFORE TAX) PRESENT VALUE RETURN	(LESS) INCOME TAX	RETURN AFTER TAX	DISCOUNT FACTOR	(AFTER TAX) PRESENT VALUE INVEST.	(AFTER TAX) PRESENT VALUE RETURN
1982	24158.	0.	0.	0.	0.	1.0000	24158.	0.	0.	0.	1.0000	24158.	0.
1983	54553.	0.	0.	0.	0.	0.8360	45605.	0.	0.	0.	0.8360	45605.	0.
1984	55972.	0.	0.	0.	0.	0.6988	39115.	0.	0.	0.	0.6988	39115.	0.
1985	32250.	1055.	8801.	5517.	15373.	0.5842	18841.	8981.	0.	15373.	0.5842	18841.	8981.
1986	0.	3596.	17602.	10822.	32020.	0.4884	0.	15638.	0.	32020.	0.4884	0.	15638.
1987	0.	6219.	17602.	10200.	34021.	0.4083	0.	13890.	0.	34021.	0.4083	0.	13890.
1988	0.	13144.	17602.	9250.	39996.	0.3413	0.	13650.	0.	39996.	0.3413	0.	13650.
1989	0.	17678.	17602.	8146.	43426.	0.2853	0.	12390.	0.	43426.	0.2853	0.	12390.
1990	0.	20725.	17602.	7043.	45370.	0.2385	0.	10821.	0.	45370.	0.2385	0.	10821.
1991	0.	24659.	17602.	5940.	48200.	0.1994	0.	9610.	0.	48200.	0.1994	0.	9610.
1992	0.	27849.	17602.	4836.	50287.	0.1667	0.	8382.	0.	50287.	0.1667	0.	8382.
1993	0.	31154.	17602.	3733.	52488.	0.1393	0.	7314.	0.	52488.	0.1393	0.	7314.
1994	0.	34745.	17602.	2629.	56976.	0.1165	0.	6637.	0.	56976.	0.1165	0.	6637.
1995	0.	46825.	8801.	1526.	57152.	0.0974	0.	5565.	0.	57152.	0.0974	0.	5565.
1996	0.	56694.	0.	634.	57328.	0.0814	0.	4667.	0.	57328.	0.0814	0.	4667.
1997	0.	57176.	0.	153.	57328.	0.0681	0.	3901.	0.	57328.	0.0681	0.	3901.
1998	0.	57328.	0.	0.	57328.	0.0569	0.	3261.	0.	57328.	0.0569	0.	3261.
1999	-6001.	57328.	0.	0.	57328.	0.0476	-285.	2726.	0.	57328.	0.0476	-285.	2726.
TOTAL	160932.				704622.		127433.	127433.		704622.		127433.	127433.

***** INTERNAL RATE OF RETURN ***** 19.62 PER CENT (BEFORE TAX) 19.62 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 5.38 YEAR (BEFORE TAX) 5.38 YEAR (AFTER TAX)
(THE YEAR WHEN THE TOTAL CAPITAL COST WILL BE PAID OUT BY ACCUMULATED TOTAL RETURN, FROM THE BEG. OF OPERATION)

CAPITAL REQUIREMENTS		SOURCE OF FUNDS	
LAND COST	373.	OWN CAPITAL	44097.
CONSTRUCTED FACILITIES	153841.	LONG TERM DEBT	137920.
PRE-INVEST AND START-UP EXP.	7091.	SHORT TERM DEBT	0.
INTEREST DURING CONSTRUCTION	15084.	FINANCIAL RESOURCES	182017.
TOTAL FIXED CAPITAL	176389.		
INITIAL WORKING CAPITAL	5628.		
TOTAL CAPITAL COST	182017.		

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***

PROFITABILITY AND FINANCIAL INDICATORS

(CASE-A : UTILITIES CENTER IS SEPARATED) (US$ 1000)

YEAR	(1) AFT TAX PROFIT -TO- SALES REV (PCT)	(2) AFT TAX PROFIT -TO- S/H EQUITY (PCT)	(3) BFR TAX PROFIT -TO- INVESTMNT (PCT)	(4) AFT TAX PROFIT -TO- S/CAPITAL (PCT)	(5) CURRENT RATIO	(6) QUICK RATIO	(7) DEBT SERVICE RATIO	(8) L/T DEBT -TO- S/H EQUITY	(9)* PROFIT B.E.P. CAPACITY UTILIZE (PCT)	(10)* CASH B.E.P. SALES PRICE (PRICE)	(11)* CASH B.E.P. CAPACITY UTILIZE (PCT)
1985	2.0	2.3	0.6	2.4	1.69	1.41	2.36	74./ 26.	26.4	703.6	16.4
1986	3.2	7.4	2.0	8.2	1.85	1.66	1.84	71./ 29.	56.5	697.8	39.6
1987	5.2	11.3	3.4	14.1	2.16	1.99	1.59	66./ 34.	55.5	716.0	45.7
1988	9.6	19.3	7.2	29.8	2.76	2.59	1.74	57./ 43.	54.0	700.6	48.1
1989	12.1	20.6	9.7	40.1	3.53	3.36	1.98	48./ 52.	52.2	682.3	46.4
1990	13.7	19.5	11.4	47.0	4.40	4.24	2.18	37./ 63.	50.5	670.5	44.7
1991	15.5	18.8	13.5	55.9	5.36	5.19	2.44	28./ 72.	48.8	657.2	43.0
1992	16.8	17.5	15.3	63.2	6.42	6.25	2.70	19./ 81.	47.1	646.8	41.3
1993	18.2	16.4	17.1	70.6	7.55	7.38	3.00	11./ 89.	45.4	636.8	39.5
1994	20.0	16.2	20.2	85.3	9.00	8.82	3.47	4./ 96.	43.7	623.7	37.8
1995	25.4	17.1	25.7	106.2	13.09	12.87	3.99	1./ 99.	28.4	613.8	34.5
1996	30.8	17.2	31.1	128.6	19.14	18.87	7.34	0./100.	13.6	584.7	24.5
1997	31.1	14.8	31.4	129.7	25.74	25.43	21.23	0./100.	12.8	562.5	16.7
1998	31.2	12.9	31.5	130.0	29.41	29.09	**********	0./100.	12.6	550.7	12.6
1999	31.2	11.4	31.5	130.0	33.07	32.75	**********	0./100.	12.6	550.7	12.6
AVERAGE1	17.7	14.8	16.8	69.3	11.01	10.79	**********	28./ 72.	37.5	639.8	33.6
AVERAGE2	19.7	15.0	16.8	69.3	9.60	9.40	3.38	19./ 81.			

(AVERAGE1) : SUM OF ANNUAL FIGURES OF PERCENTAGE AND RATIO IS DIVIDED BY NO. OF YEARS(SIMPLE AVERAGE)

(AVERAGE2) : AVERAGE FIGURES ARE CALCULATED BY ACTUAL VALUES ACCUMULATED OVER THE PROJECT LIFE(WEIGHTED AVERAGE)

* NOTE FOR (9)(10)(11)

WHEN THERE ARE TWO OR MORE PRODUCTS, AND DURING THE YEARS WHEN ALL OF PRODUCTS ARE NOT PRODUCED AT THE SAME RATE OF CAPACITY UTILIZATION, ABOVE BREAK-EVEN-POINTS CANNOT GIVE CORRECT FIGURES.

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***
PRODUCTION COST STATEMENTS
(CASE-A : UTILITIES CENTER IS SEPARATED) (US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
PRODUCTION	70500.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
ETHANE	30787.	62317.	65374.	74501.	79741.	82711.	87034.	90222.	93585.	100441.	100441.	100441.	100441.	100441.	100441.
CATALYSTS & CHEMICALS	353.	714.	749.	853.	913.	947.	997.	1033.	1072.	1150.	1150.	1150.	1150.	1150.	1150.
RAW MATERIAL COST	31140.	63031.	66122.	75354.	80654.	83658.	88031.	91255.	94656.	101591.	101591.	101591.	101591.	101591.	101591.
FUEL GAS	464.	939.	985.	1123.	1202.	1247.	1312.	1360.	1411.	1514.	1514.	1514.	1514.	1514.	1514.
POWER	190.	385.	403.	460.	492.	510.	537.	557.	578.	620.	620.	620.	620.	620.	620.
STEAM (42K)	1081.	2188.	2295.	2615.	2799.	2904.	3055.	3167.	3285.	3526.	3526.	3526.	3526.	3526.	3526.
BFW	1505.	3047.	3196.	3642.	3899.	4044.	4255.	4411.	4575.	4911.	4911.	4911.	4911.	4911.	4911.
CONDENSATE	-825.	-1670.	-1751.	-1996.	-2136.	-2216.	-2332.	-2417.	-2507.	-2691.	-2691.	-2691.	-2691.	-2691.	-2691.
COOLING WATER	1303.	2637.	2766.	3153.	3374.	3500.	3683.	3818.	3960.	4250.	4250.	4250.	4250.	4250.	4250.
INERT GAS	233.	471.	494.	563.	603.	625.	658.	682.	707.	759.	759.	759.	759.	759.	759.
INSTR. & PLANT AIR	135.	273.	286.	326.	349.	362.	381.	395.	409.	439.	439.	439.	439.	439.	439.
WASTE WATER TREATMENT ETC.	310.	628.	659.	751.	803.	833.	877.	909.	943.	1012.	1012.	1012.	1012.	1012.	1012.
UTILITIES COST	4396.	8897.	9333.	10637.	11385.	11809.	12426.	12881.	13361.	14340.	14340.	14340.	14340.	14340.	14340.
VARIABLE COST	35535.	71928.	75456.	85991.	92039.	95467.	100457.	104136.	108017.	115931.	115931.	115931.	115931.	115931.	115931.
DEPRECIATION (PROCESS PLANT)	7692.	15384.	15384.	15384.	15384.	15384.	15384.	15384.	15384.	15384.	7692.	0.	0.	0.	0.
DEPRECIATION (PRE-INVEST)	355.	709.	709.	709.	709.	709.	709.	709.	709.	709.	355.	0.	0.	0.	0.
DEPRECIATION (INTEREST DCR.)	754.	1508.	1508.	1508.	1508.	1508.	1508.	1508.	1508.	1508.	754.	0.	0.	0.	0.
DEPRECIATION	8801.	17602.	17602.	17602.	17602.	17602.	17602.	17602.	17602.	17602.	8801.	0.	0.	0.	0.
AMORTIZATION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPRECIATION & AMORTIZATION	8801.	17602.	17602.	17602.	17602.	17602.	17602.	17602.	17602.	17602.	8801.	0.	0.	0.	0.
LABOR COST	334.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.
OVERHEAD	334.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.	667.
EMPLOYMENT COST	667.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.	1334.
MAINTENANCE COST	2308.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.	4615.
TAX & INSURANCE	1154.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.	2308.
OTHER FIXED COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIRECT FIXED COST	4128.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.	8257.
EX-FACTORY PRODUCTION COST	48465.	97786.	101314.	111849.	117898.	121325.	126315.	129995.	133876.	141789.	132989.	124188.	124188.	124188.	124188.
UNIT DIRECT OPERATING COST	0.6874	0.6853	0.6768	0.6556	0.6457	0.6406	0.6338	0.6292	0.6247	0.6165	0.5782	0.5399	0.5399	0.5399	0.5399
HEAD OFFICE EXP.	969.	1956.	2026.	2237.	2358.	2427.	2526.	2600.	2678.	2836.	2660.	2484.	2484.	2484.	2484.
INTEREST ON LOAN NO.1	794.	1468.	1310.	1151.	992.	833.	675.	516.	357.	198.	40.	0.	0.	0.	0.
INTEREST ON LOAN NO.2	1852.	3612.	3241.	2871.	2500.	2130.	1759.	1389.	1019.	648.	278.	0.	0.	0.	0.
INTEREST ON LOAN NO.3	1852.	3704.	3612.	3241.	2871.	2500.	2130.	1759.	1389.	1019.	648.	278.	0.	0.	0.
INTEREST ON LOAN NO.4	794.	1588.	1588.	1548.	1389.	1230.	1072.	913.	754.	595.	437.	278.	119.	0.	0.
INTEREST ON LOAN NO.5	225.	450.	450.	439.	394.	349.	304.	259.	214.	169.	124.	79.	34.	0.	0.
INTEREST ON LONG-TERM DEBT	5517.	10822.	10200.	9250.	8146.	7043.	5940.	4836.	3733.	2629.	1526.	634.	153.	0.	0.
INTEREST ON SHORT-TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL PRODUCTION COST	54951.	110564.	113541.	123336.	128402.	130795.	134781.	137431.	140286.	147255.	137175.	127306.	126824.	126672.	126672.
UNIT PRODUCTION COST	0.7794	0.7748	0.7585	0.7230	0.7032	0.6906	0.6763	0.6652	0.6546	0.6402	0.5964	0.5535	0.5514	0.5507	0.5507

ATTACHMENT VII–2

FINANCIAL STATEMENTS FOR THE ETHYLENE PROJECT

(Case–B Evaluation Method)

Income Statements
Funds Flow Statements
Balance Sheet
Production and Sales Plan
Production Cost Statement
IRR Calculation
Profitability and Financial Indicators

Note:	Ethylene Sales Price	:	$800/t
	Feedstock Ethane Price	:	$350/t

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***

INCOME STATEMENTS (FOR YEARS ENDING DECEMBER 31)

(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
PRODUCTION AND SALES															
CAPACITY	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.
CAPACITY UTILIZATION	0.307	0.620	0.651	0.742	0.794	0.823	0.867	0.898	0.932	1.000	1.000	1.000	1.000	1.000	1.000
PRODUCTION	70500.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
INCREASE IN INVENTORIES	3500.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME	67000.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
SALES REVENUE	53600.	114160.	119760.	136480.	146080.	151520.	159440.	165280.	171440.	184000.	184000.	184000.	184000.	184000.	184000.
COST OF SALES	44549.	94659.	97580.	107033.	112313.	115523.	120195.	123640.	127274.	134683.	124006.	113329.	113329.	113329.	113329.
VARIABLE COST	31072.	63050.	65971.	75424.	80704.	83914.	88586.	92031.	95665.	103074.	103074.	103074.	103074.	103074.	103074.
DEPRECIATION & AMORTIZATION	10677.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	10677.	0.	0.	0.	0.
OTHER FIXED COST	5128.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.
(INC) IN PRODUCT INVENTORIES	-2327.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GROSS PROFIT OR (LOSS) ON SALES	9051.	19501.	22180.	29447.	33767.	35997.	39245.	41640.	44166.	49317.	59994.	70671.	70671.	70671.	70671.
LESS. SALES EXPENSES	938.	1893.	1952.	2141.	2246.	2310.	2404.	2473.	2545.	2694.	2480.	2267.	2267.	2267.	2267.
OPERATING PROFIT OR (LOSS)	8113.	17607.	20228.	27306.	31520.	33687.	36841.	39167.	41621.	46623.	57514.	68404.	68404.	68404.	68404.
LESS. INTEREST															
ON LONG TERM DEBT	6663.	13070.	12316.	11165.	9832.	8499.	7167.	5834.	4501.	3169.	1836.	760.	181.	0.	0.
ON SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NET PROFIT OR (LOSS) BEFORE TAX	1450.	4537.	7912.	16141.	21688.	25188.	29675.	33333.	37120.	43455.	55678.	67644.	68223.	68404.	68404.
LESS. INCOME TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NET PROFIT OR (LOSS) AFTER TAX	1450.	4537.	7912.	16141.	21688.	25188.	29675.	33333.	37120.	43455.	55678.	67644.	68223.	68404.	68404.

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***
FUNDS FLOW STATEMENTS (FOR YEARS ENDING DECEMBER 31)
(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SOURCES OF FUNDS	32087.	74869.	74869.	61223.	43278.	41976.	49936.	53587.	55474.	58826.	60986.	63465.	68977.	68191.	68404.	68404.	68404.	68404.
CASH GENERATED FROM OPERATION	0.	0.	0.	18790.	38961.	41582.	48660.	52874.	55041.	58195.	60521.	62975.	67977.	68191.	68404.	68404.	68404.	68404.
PROFIT BEFORE TAX, INTEREST	0.	0.	0.	8113.	17607.	20228.	27306.	31520.	33687.	36841.	39167.	41621.	46623.	57514.	68404.	68404.	68404.	68404.
DEPRECIATION & AMORTIZATION	0.	0.	0.	10677.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	10677.	0.	0.	0.	0.
FINANCIAL RESOURCES	32087.	74869.	74869.	38239.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHARE CAPITAL	8022.	18717.	18717.	8022.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LONG TERM DEBT	24065.	56152.	56152.	30217.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCREASE IN ACCT PAYABLE	0.	0.	0.	4195.	4317.	394.	1276.	713.	433.	631.	465.	491.	1000.	0.	0.	0.	0.	0.
USES OF FUNDS	31972.	72578.	74306.	53268.	30070.	26787.	30313.	27920.	25968.	25004.	23362.	22077.	21657.	17291.	9397.	3203.	0.	0.
INVESTMENT IN FIXED ASSET	31972.	72578.	74306.	35055.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAND AND SITE IMPROVEMENT	373.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CONSTRUCTED FACILITIES	27991.	65312.	65312.	27991.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PRE-INVEST. & START-UP EXP	864.	864.	2592.	4321.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INTEREST DURING CONSTRUCTN	2744.	6402.	6402.	2744.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCREASE IN CURRENT ASSET OTHER THAN CASH	0.	0.	0.	10347.	8978.	834.	2489.	1429.	810.	1179.	870.	917.	1870.	0.	0.	0.	0.	0.
INCR(DECR) ACC. T RECEIVABLE	0.	0.	0.	7236.	8176.	756.	2257.	1296.	734.	1069.	788.	832.	1696.	0.	0.	0.	0.	0.
INCR(DECR) IN INVENTORIES																		
PRODUCTS	0.	0.	0.	2327.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MATERIALS	0.	0.	0.	784.	802.	76.	232.	133.	76.	110.	81.	86.	174.	0.	0.	0.	0.	0.
DEBT SERVICES	0.	0.	0.	7867.	21092.	25953.	27823.	26491.	25158.	23825.	22493.	21160.	19827.	17291.	9397.	3203.	0.	0.
REPAYMENT OF LONG TERM DEBT	0.	0.	0.	1203.	8022.	13637.	16659.	16659.	16659.	16659.	16659.	16659.	16659.	15455.	8637.	3022.	0.	0.
REPAYMENT OF SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INTEREST ON LONG TERM DEBT	0.	0.	0.	6663.	13070.	12316.	11165.	9832.	8499.	7167.	5834.	4501.	3169.	1836.	760.	181.	0.	0.
INTEREST ON SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCOME TAX PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIVIDENDS PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CASH INCREASE OR (DECREASE)	115.	2291.	563.	7955.	13208.	15190.	19623.	25667.	29506.	33822.	37624.	41388.	47280.	50900.	59007.	65201.	68404.	68404.
BEGINNING CASH BALANCE	0.	115.	2406.	2968.	10923.	24132.	39321.	58945.	84612.	114118.	147939.	185564.	226952.	274232.	325132.	384139.	449341.	517745.
ENDING CASH BALANCE	115.	2406.	2968.	10923.	24132.	39321.	58945.	84612.	114118.	147939.	185564.	226952.	274232.	325132.	384139.	449341.	517745.	586149.

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***
BALANCE SHEET (FOR YEARS ENDING DECEMBER 31)
(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
ASSETS	32087.	106955.	181824.	224504.	225337.	220006.	220765.	226508.	235470.
CURRENT ASSETS	115.	2406.	2968.	21270.	43456.	59480.	81593.	108689.	139005.
CASH	115.	2406.	2968.	10923.	24132.	39321.	58545.	84612.	114118.
ACCOUNTS RECEIVABLE	0.	0.	0.	7236.	15412.	16168.	18425.	19721.	20455.
INVENTORIES									
PRODUCTS	0.	0.	0.	2327.	2327.	2327.	2327.	2327.	2327.
MATERIALS	0.	0.	0.	784.	1586.	1664.	1896.	2029.	2105.
NET FIXED ASSETS	31972.	104550.	178856.	203234.	181880.	160526.	139173.	117819.	96465.
INVESTMENT	31972.	104550.	178856.	213911.	213911.	213911.	213911.	213911.	213911.
LAND & SITE IMPROVEMENT	373.	373.	373.	373.	373.	373.	373.	373.	373.
CONSTRUCTED FACILITIES	27991.	93302.	158614.	186605.	186605.	186605.	186605.	186605.	186605.
PRE-INVEST. & START-UP EXP	864.	1728.	4321.	8641.	8641.	8641.	8641.	8641.	8641.
INTEREST DURING CONSTRUCTN	2744.	9146.	15548.	18292.	18292.	18292.	18292.	18292.	18292.
LESS.DEPRECIATN & AMORTIZTN	0.	0.	0.	10677.	32031.	53384.	74738.	96092.	117446.
LIABILITIES	24065.	80217.	136368.	169577.	165872.	152630.	137247.	121302.	105076.
CURRENT LIABILITIES	0.	0.	1203.	12216.	22149.	25565.	26841.	27554.	27987.
ACCOUNTS PAYABLE	0.	0.	0.	4195.	8512.	8906.	10182.	10895.	11328.
INCOME TAX PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIVIDENDS PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.
CURRENT PORTION OF DEBT									
LONG TERM DEBT	0.	0.	1203.	8022.	13637.	16659.	16659.	16659.	16659.
SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.
FIXED LIABILITIES	24065.	80217.	135165.	157360.	143724.	127065.	110406.	93748.	77089.
LONG TERM DEBT BALANCE	24065.	80217.	135165.	157360.	143724.	127065.	110406.	93748.	77089.
STOCK HOLDERS EQUITY	8022.	26739.	45456.	54927.	59465.	67377.	83518.	105206.	130394.
SHARE CAPITAL	8022.	26739.	45456.	53478.	53478.	53478.	53478.	53478.	53478.
RETAINED ERNINGS	0.	0.	0.	1450.	5987.	13899.	30040.	51729.	76916.

	1991	1992	1993	1994	1995	1996	1997	1998	1999
ASSETS	249117.	266257.	287209.	315006.	355228.	414236.	479437.	547641.	616246.
CURRENT ASSETS	174006.	212500.	254805.	303956.	354855.	413863.	479064.	547466.	615873.
CASH	147939.	185564.	226952.	274232.	325132.	384139.	449341.	517745.	586149.
ACCOUNTS RECEIVABLE	21524.	22313.	23144.	24840.	24640.	24840.	24840.	24840.	24840.
INVENTORIES									
PRODUCTS	2327.	2327.	2327.	2327.	2327.	2327.	2327.	2327.	2327.
MATERIALS	2215.	2296.	2382.	2556.	2556.	2556.	2556.	2556.	2556.
NET FIXED ASSETS	75111.	53758.	32404.	11050.	373.	373.	373.	373.	373.
INVESTMENT	213911.	213911.	213911.	213911.	213911.	213911.	213911.	213911.	213911.
LAND & SITE IMPROVEMENT	373.	373.	373.	373.	373.	373.	373.	373.	373.
CONSTRUCTED FACILITIES	186605.	186605.	186605.	186605.	186605.	186605.	186605.	186605.	186605.
PRE-INVEST. & START-UP EXP	8641.	8641.	8641.	8641.	8641.	8641.	8641.	8641.	8641.
INTEREST DURING CONSTRUCTN	18292.	18292.	18292.	18292.	18292.	18292.	18292.	18292.	18292.
LESS.DEPRECIATN & AMORTIZTN	138800.	160153.	181507.	202861.	213538.	213538.	213538.	213538.	213538.
LIABILITIES	89048.	72855.	56687.	41029.	25574.	16937.	13915.	13915.	13915.
CURRENT LIABILITIES	28618.	29083.	29573.	29370.	22552.	16937.	13915.	13915.	13915.
ACCOUNTS PAYABLE	11959.	12424.	12915.	13915.	13915.	13915.	13915.	13915.	13915.
INCOME TAX PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIVIDENDS PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.
CURRENT PORTION OF DEBT									
LONG TERM DEBT	16659.	16659.	16659.	15455.	8637.	3022.	0.	0.	0.
SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.
FIXED LIABILITIES	60431.	43772.	27114.	11659.	3022.	-0.	-0.	-0.	-0.
LONG TERM DEBT BALANCE	60431.	43772.	27114.	11659.	3022.	-0.	-0.	-0.	-0.
STOCK HOLDERS EQUITY	160069.	193402.	230522.	273977.	329655.	397299.	465522.	533926.	602331.
SHARE CAPITAL	53478.	53478.	53478.	53478.	53478.	53478.	53478.	53478.	53478.
RETAINED ERNINGS	106591.	139925.	177044.	220499.	276177.	343821.	412044.	480449.	548853.

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***

PRODUCTION AND SALES PLAN

(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CAPACITY	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.	230000.
CAPACITY UTILIZATION	0.307	0.620	0.651	0.742	0.794	0.823	0.867	0.898	0.932	1.000	1.000	1.000	1.000	1.000	1.00
PRODUCTION	70500.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
INCREASE IN INVENTORY	3500.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME	67000.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
UNIT PRICE	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.800
SALES REVENUE	53600.	114160.	119760.	136480.	146080.	151520.	159440.	165280.	171440.	184000.	184000.	184000.	184000.	184000.	184000.
*** TOTAL SALES REVENUE ***	53600.	114160.	119760.	136480.	146080.	151520.	159440.	165280.	171440.	184000.	184000.	184000.	184000.	184000.	184000.
*** TOTAL SALES VOLUME ***	67000.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
*** AVERAGE SALES,PRICE ***	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000	0.8000

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***
PRODUCTION COST STATEMENTS
(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
PRODUCTION	70500.	142700.	149700.	170600.	182600.	189400.	199300.	206600.	214300.	230000.	230000.	230000.	230000.	230000.	230000.
ETHANE	30787.	62317.	65374.	74501.	79741.	82711.	87034.	90222.	93585.	100441.	100441.	100441.	100441.	100441.	100441.
CATALYSTS & CHEMICALS	494.	999.	1048.	1194.	1278.	1326.	1395.	1446.	1500.	1610.	1610.	1610.	1610.	1610.	1610.
RAW MATERIAL COST	31281.	63316.	66422.	75695.	81020.	84037.	88429.	91668.	95085.	102051.	102051.	102051.	102051.	102051.	102051.
FUEL GAS (1)	1925.	3896.	4087.	4657.	4985.	5171.	5441.	5640.	5850.	6279.	6279.	6279.	6279.	6279.	6279.
FUEL GAS (2)	902.	1762.	1919.	2088.	2245.	2245.	2245.	2245.	2245.	2245.	2245.	2245.	2245.	2245.	2245.
RAW WATER (1)	66.	133.	139.	159.	170.	176.	185.	192.	199.	214.	214.	214.	214.	214.	214.
RAW WATER (2)	63.	122.	133.	145.	156.	156.	156.	156.	156.	156.	156.	156.	156.	156.	156.
UTILITIES SALE (TO VCM/HDPE)	-3164.	-6179.	-6730.	-7320.	-7871.	-7871.	-7871.	-7871.	-7871.	-7871.	-7871.	-7871.	-7871.	-7871.	-7871.
UTILITIES COST	-209.	-266.	-451.	-271.	-315.	-123.	156.	362.	580.	1023.	1023.	1023.	1023.	1023.	1023.
VARIABLE COST	31072.	61050.	65971.	75424.	80704.	83914.	88586.	92031.	95665.	103074.	103074.	103074.	103074.	103074.	103074.
DEPRECIATION (PROCESS PLANT)	9330.	18660.	18660.	18660.	18660.	18660.	18660.	18660.	18660.	18660.	9330.	0.	0.	0.	0.
DEPRECIATION (PRE-INVEST)	432.	864.	864.	864.	864.	864.	864.	864.	864.	864.	432.	0.	0.	0.	0.
DEPRECIATION (INTEREST DUR.)	915.	1829.	1829.	1829.	1829.	1829.	1829.	1829.	1829.	1829.	915.	0.	0.	0.	0.
DEPRECIATION	10677.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	10677.	0.	0.	0.	0.
AMORTIZATION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPRECIATION & AMORTIZATION	10677.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	21354.	10677.	0.	0.	0.	0.
LABOR COST	465.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.
OVERHEAD	465.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.	929.
EMPLOYMENT COST	929.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.	1858.
MAINTENANCE COST	2799.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.	5598.
TAX & INSURANCE	1400.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.	2799.
OTHER FIXED COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIRECT FIXED COST	5126.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.	10255.
EX-FACTORY PRODUCTION COST	46877.	94659.	97580.	107033.	112313.	115523.	120195.	123640.	127274.	134683.	124006.	113329.	113329.	113329.	113329.
UNIT DIRECT OPERATING COST	0.6649	0.6633	0.6518	0.6274	0.6151	0.6099	0.6031	0.5984	0.5939	0.5856	0.5392	0.4927	0.4927	0.4927	0.4927
HEAD OFFICE EXP.	936.	1893.	1952.	2141.	2246.	2310.	2404.	2473.	2545.	2694.	2480.	2267.	2267.	2267.	2267.
INTEREST ON LOAN NO.1	963.	1781.	1588.	1396.	1203.	1011.	818.	626.	433.	241.	48.	0.	0.	0.	0.
INTEREST ON LOAN NO.2	2246.	4380.	3931.	3481.	3032.	2583.	2134.	1685.	1235.	786.	337.	0.	0.	0.	0.
INTEREST ON LOAN NO.3	2246.	4492.	4380.	3931.	3481.	3032.	2583.	2134.	1685.	1235.	786.	337.	0.	0.	0.
INTEREST ON LOAN NO.4	963.	1925.	1925.	1877.	1685.	1492.	1300.	1107.	914.	722.	529.	337.	144.	0.	0.
INTEREST ON LOAN NO.5	246.	492.	492.	480.	431.	381.	332.	283.	234.	185.	135.	86.	37.	0.	0.
INTEREST ON LONG-TERM DEBT	6663.	13070.	12316.	11165.	9832.	8499.	7167.	5834.	4501.	3169.	1836.	760.	181.	0.	0.
INTEREST ON SHORT-TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL PRODUCTION COST	54476.	109623.	111848.	120339.	124392.	126332.	129765.	131947.	134320.	140545.	128322.	116356.	115777.	115596.	115596.
UNIT PRODUCTION COST	0.7727	0.7682	0.7471	0.7054	0.6812	0.6670	0.6511	0.6387	0.6268	0.6111	0.5579	0.5059	0.5034	0.5026	0.5026

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***
IRR CALCULATION ON TOTAL INVESTMENT
(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

YEAR	TOTAL INVESTMENT	PROFIT BEFORE TAX	DEPRECIATN	INTEREST ON L-T DEBT	RETURN BEFORE TAX	DISCOUNT FACTOR	(BEFORE TAX) PRESENT VALUE INVEST.	RETURN	(LESS) INCOME TAX	RETURN AFTER TAX	DISCOUNT FACTOR	(AFTER TAX) PRESENT VALUE INVEST.	RETURN
1982	29228.	0.	0.	0.	0.	1.0000	29228.	0.	0.	0.	1.0000	29228.	0.
1983	66176.	0.	0.	0.	0.	0.8359	55319.	0.	0.	0.	0.8359	55319.	0.
1984	67904.	0.	0.	0.	0.	0.6988	47451.	0.	0.	0.	0.6988	47451.	0.
1985	38463.	1450.	16077.	6663.	16790.	0.5842	22468.	10976.	0.	16790.	0.5842	22468.	10976.
1986	0.	4537.	21354.	13070.	36961.	0.4883	0.	19025.	0.	38961.	0.4883	0.	19025.
1987	0.	7912.	21354.	12316.	41582.	0.4082	0.	16974.	0.	41582.	0.4082	0.	16974.
1988	0.	16141.	21354.	11165.	46660.	0.3412	0.	16604.	0.	46660.	0.3412	0.	16604.
1989	0.	21668.	21354.	9632.	52874.	0.2853	0.	15082.	0.	52874.	0.2853	0.	15082.
1990	0.	25188.	21354.	8499.	55041.	0.2385	0.	13125.	0.	55041.	0.2385	0.	13125.
1991	0.	29675.	21354.	7167.	58195.	0.1993	0.	11600.	0.	58195.	0.1993	0.	11600.
1992	0.	33333.	21354.	5634.	60521.	0.1666	0.	10085.	0.	60521.	0.1666	0.	10085.
1993	0.	37120.	21354.	4501.	62975.	0.1393	0.	8772.	0.	62975.	0.1393	0.	8772.
1994	0.	43455.	21354.	3169.	67977.	0.1164	0.	7915.	0.	67977.	0.1164	0.	7915.
1995	0.	55676.	10677.	1836.	68191.	0.0973	0.	6638.	0.	68191.	0.0973	0.	6638.
1996	0.	67644.	0.	760.	68404.	0.0814	0.	5566.	0.	68404.	0.0814	0.	5566.
1997	0.	68223.	0.	181.	68404.	0.0680	0.	4653.	0.	68404.	0.0680	0.	4653.
1998	0.	68404.	0.	0.	68404.	0.0569	0.	3889.	0.	68404.	0.0569	0.	3889.
1999	-6525.	68404.	0.	0.	68404.	0.0475	-310.	3251.	0.	68404.	0.0475	-310.	3251.
TOTAL	195246.				847384.		154156.	154156.		847384.		154156.	154156.

***** INTERNAL RATE OF RETURN ***** 19.63 PER CENT (BEFORE TAX) 19.63 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 5.35 YEAR (BEFORE TAX) 5.35 YEAR (AFTER TAX)
(THE YEAR WHEN THE TOTAL CAPITAL COST WILL BE PAID OUT BY ACCUMULATED TOTAL RETURN, FROM THE BEG. OF OPERATION)

CAPITAL REQUIREMENTS		SOURCE OF FUNDS	
LAND COST	373.	OWN CAPITAL	53478.
PLANT COST	186605.	LONG TERM DEBT	166585.
PRE-INVEST AND START-UP EXP.	8041.	SHORT TERM DEBT	0.
INTEREST DURING CONSTRUCTION	18292.	FINANCIAL RESOURCES	220063.
TOTAL FIXED CAPITAL	213911.		
INITIAL WORKING CAPITAL	6152.		
TOTAL CAPITAL COST	220063.		

*** FINANCIAL PROJECTIONS OF PTT ETHYLENE PLANT PROJECT ***

PROFITABILITY AND FINANCIAL INDICATORS

(BASE : UTILITIES CENTER IS INTEGRATED) (US$ 1000)

YEAR	(1) AFT TAX PROFIT -TO- SALES REV (PCT)	(2) AFT TAX PROFIT -TO- S/H EQUITY (PCT)	(3) BFR TAX PROFIT -TO- INVESTMT (PCT)	(4) AFT TAX PROFIT -TO- S/CAPITAL (PCT)	(5) CURRENT RATIO	(6) QUICK RATIO	(7) DEBT SERVICE RATIO	(8) L/T DEBT -TO- S/H EQUITY	(9)* PROFIT B.E.P. CAPACITY UTILIZE (PCT)	(10)* CASH B.E.P. SALES PRICE (PRICE)	(11)* CASH B.E.P. CAPACITY UTILIZE (PCT)
1985	2.7	2.6	0.7	2.7	1.74	1.49	2.39	74./ 26.	28.2	671.7	16.3
1986	4.0	7.6	2.1	8.5	1.96	1.79	1.85	71./ 29.	56.3	674.8	39.5
1987	6.6	11.7	3.6	14.8	2.33	2.17	1.60	65./ 35.	55.2	695.6	45.5
1988	11.8	19.3	7.3	30.2	3.04	2.88	1.75	57./ 43.	53.9	677.9	47.9
1989	14.8	20.6	5.9	40.6	3.94	3.79	2.00	47./ 53.	52.1	655.5	46.2
1990	16.6	19.3	11.4	47.1	4.97	4.61	2.19	37./ 63.	50.6	642.2	44.7
1991	16.6	18.5	13.5	55.5	6.08	5.92	2.44	27./ 73.	49.1	627.5	43.1
1992	20.2	17.2	15.1	62.3	7.31	7.15	2.69	18./ 82.	47.5	615.9	41.6
1993	21.7	16.1	16.9	69.4	8.62	8.46	2.98	11./ 89.	45.9	604.9	40.0
1994	23.6	15.9	19.7	81.3	10.35	10.18	3.43	4./ 96.	44.5	590.7	38.5
1995	30.3	16.9	25.3	104.1	15.74	15.52	3.94	1./ 99.	29.0	578.7	35.1
1996	33.8	17.0	30.7	126.5	24.44	24.15	7.28	-0./100.	14.0	543.4	25.0
1997	37.1	14.7	31.0	127.6	34.43	34.08	21.36	-0./100.	13.3	516.5	17.1
1998	37.2	12.8	31.1	127.9	39.34	38.99	**********	-0./100.	13.0	502.6	13.0
1999	37.2	11.4	31.1	127.9	44.26	43.91	**********	-0./100.	13.0	502.6	13.0
AVERAGE1	21.3	14.8	16.6	68.4	13.90	13.68	**********	28./ 72.	37.7	606.7	33.8
AVERAGE2	23.6	14.9	16.6	68.4	11.20	11.00	3.37	19./ 81.			

(AVERAGE1) : SUM OF ANNUAL FIGURES OF PERCENTAGE AND RATIO IS DIVIDED BY NO. OF YEARS(SIMPLE AVERAGE)
(AVERAGE2) : AVERAGE FIGURES ARE CALCULATED BY ACTUAL VALUES ACCUMULATED OVER THE PROJECT LIFE(WEIGHTED AVERAGE)

* NOTE FOR (9)(10)(11)
WHEN THERE ARE TWO OR MORE PRODUCTS, AND DURING THE YEARS WHEN ALL OF PRODUCTS ARE NOT PRODUCED AT THE SAME RATE OF CAPACITY UTILIZATION, ABOVE BREAK-EVEN-POINTS CANNOT GIVE CORRECT FIGURES.

ATTACHMENT VII-3

FINANCIAL STATEMENTS FOR THE VCM PROJECT

Income Statement

Funds Flow Statement

Balance Sheet

Production and Sales Plan

Production Cost Statement

IRR Calculation

Profitability and Financial Indicators

Note : Ethylene Price : $800/t

*** THAI VCM PROJECT ***
INCOME STATEMENTS (FOR YEARS ENDING DECEMBER 31)
- BASE CASE - (US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SALES REVENUE	28102.	61277.	66741.	72596.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.
COST OF SALES	27124.	59658.	63048.	66679.	70069.	70069.	70069.	70069.	70069.	70069.	63323.	56577.	56577.	56577.	56577.
VARIABLE COST	19467.	38014.	41403.	45035.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.
DEPRECIATION & AMORTIZATION	6746.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	6746.	0.	0.	0.	0.
OTHER FIXED COST	4076.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.
(INC.) IN PRODUCT INVENTORIES	-3165.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
GROSS PROFIT OR (LOSS) ON SALES	977.	1619.	3694.	5916.	7991.	7991.	7991.	7991.	7991.	7991.	14737.	21483.	21483.	21483.	21483.
LESS. SALES EXPENSES	606.	1193.	1261.	1334.	1401.	1401.	1401.	1401.	1401.	1401.	1266.	1132.	1132.	1132.	1132.
OPERATING PROFIT OR (LOSS)	371.	426.	2433.	4583.	6589.	6589.	6589.	6589.	6589.	6589.	13470.	20351.	20351.	20351.	20351.
LESS. INTEREST															
ON LONG TERM DEBT	4238.	8414.	8069.	7370.	6523.	5675.	4828.	3980.	3133.	2285.	1438.	651.	149.	0.	0.
ON SHORT TERM DEBT	0.	0.	248.	413.	559.	345.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NET PROFIT OR (LOSS) BEFORE TAX	-3866.	-7988.	-5884.	-3201.	-492.	569.	1762.	2609.	3457.	4304.	12032.	19700.	20202.	20351.	20351.
LESS. INCOME TAX	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NET PROFIT OR (LOSS) AFTER TAX	-3866.	-7988.	-5884.	-3201.	-492.	569.	1762.	2609.	3457.	4304.	12032.	19700.	20202.	20351.	20351.

*** THAI VCM PROJECT ***

FUNDS FLOW STATEMENTS (FOR YEARS ENDING DECEMBER 31)

- BASE CASE - (US$ 1000)

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
SOURCES OF FUNDS	40585.	67642.	41277.	18327.	19560.	22862.	23193.	20081.	20081.	20081.	20081.	20081.	20216.	20351.	20351.	20351.	20351.
CASH GENERATED FROM OPERATION	0.	0.	7117.	13918.	15925.	18075.	20081.	20081.	20081.	20081.	20081.	20081.	20216.	20351.	20351.	20351.	20351.
PROFIT BEFORE TAX, INTEREST	0.	0.	371.	426.	2433.	4583.	6589.	6589.	6589.	6589.	6589.	6589.	13470.	20351.	20351.	20351.	20351.
DEPRECIATION & AMORTIZATION	0.	0.	6746.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	6746.	0.	0.	0.	0.
FINANCIAL RESOURCES	40585.	67642.	31532.	1905.	3177.	4297.	2654.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHARE CAPITAL	10146.	16911.	6764.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LONG TERM DEBT	30439.	50732.	24768.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SHORT TERM DEBT	0.	0.	0.	1905.	3177.	4297.	2654.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCREASE IN ACCT PAYABLE	0.	0.	2628.	2504.	458.	490.	458.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
USES OF FUNDS	40163.	66103.	40359.	16075.	19102.	22372.	22735.	19268.	15422.	14574.	13727.	12879.	12032.	8201.	2625.	0.	0.
INVESTMENT IN FIXED ASSET	40163.	66103.	29018.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
LAND AND SITE IMPROVEMENT	366.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CONSTRUCTED FACILITIES	35609.	59349.	23740.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
PRE-INVEST. & START-UP EXP	1356.	2035.	3391.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INTEREST DURING CONSTRUCTN	2831.	4719.	1888.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCREASE IN CURRENT ASSET OTHER THAN CASH	0.	0.	7103.	4617.	763.	817.	763.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCR(DECR) ACC T RECEIVABLE	0.	0.	3794.	4479.	738.	790.	738.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCR(DECR) IN INVENTORIES																	
PRODUCTS	0.	0.	3165.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MATERIALS	0.	0.	145.	138.	25.	27.	25.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEBT SERVICES	0.	0.	4238.	11458.	18339.	21555.	21973.	19268.	15422.	14574.	13727.	12879.	12032.	8201.	2625.	0.	0.
REPAYMENT OF LONG TERM DEBT	0.	0.	0.	3044.	8117.	10594.	10594.	10594.	10594.	10594.	10594.	10594.	10594.	7550.	2477.	0.	0.
REPAYMNT OF SHORT TERM DEBT	0.	0.	0.	0.	1905.	3177.	4297.	2654.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INTEREST ON LONG TERM DEBT	0.	0.	4238.	8414.	8069.	7370.	6523.	5675.	4828.	3980.	3133.	2285.	1438.	651.	149.	0.	0.
INTEREST ON SHORT TERM DEBT	0.	0.	0.	0.	248.	413.	559.	345.	0.	0.	0.	0.	0.	0.	0.	0.	0.
INCOME TAX PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIVIDENDS PAYMENT	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
CASH INCREASE OR (DECREASE)	422.	1539.	918.	2252.	458.	490.	458.	813.	4660.	5507.	6355.	7202.	8185.	12150.	17726.	20351.	20351.
BEGINNING CASH BALANCE	0.	422.	1961.	2880.	5132.	5589.	6080.	6537.	7350.	12010.	17517.	23872.	31074.	39258.	51408.	69134.	89485.
ENDING CASH BALANCE	422.	1961.	2880.	5132.	5589.	6080.	6537.	7350.	12010.	17517.	23872.	31074.	39258.	51408.	69134.	89485.	109836.

*** THAI VCM PROJECT ***
BALANCE SHEET (FOR YEARS ENDING DECEMBER 31)
- BASE CASE -
(US$ 1000)

	1983	1984	1985	1986	1987	1988	1989	1990	1991
ASSETS	40585.	108227.	138521.	131898.	119627.	107443.	95171.	82492.	73660.
CURRENT ASSETS	422.	1961.	9983.	16852.	18072.	19360.	20600.	21413.	26073.
CASH	422.	1961.	2880.	5132.	5589.	6080.	6537.	7350.	12010.
ACCOUNTS RECEIVABLE	0.	0.	3794.	8272.	9010.	9800.	10538.	10538.	10538.
INVENTORIES									
PRODUCTS	0.	0.	3165.	3165.	3165.	3165.	3165.	3165.	3165.
MATERIALS	0.	0.	145.	283.	308.	335.	360.	360.	360.
NET FIXED ASSETS	40163.	106266.	128538.	115046.	101554.	88063.	74571.	61079.	47587.
INVESTMENT	40163.	106266.	135284.	135284.	135284.	135284.	135284.	135284.	135284.
LAND & SITE IMPROVEMENT	366.	366.	366.	366.	366.	366.	366.	366.	366.
CONSTRUCTED FACILITIES	35609.	94958.	118698.	118698.	118698.	118698.	118698.	118698.	118698.
PRE-INVEST. & START-UP EXP	1356.	3391.	6782.	6782.	6782.	6782.	6782.	6782.	6782.
INTEREST DURING CONSTRUCTN	2831.	7550.	9438.	9438.	9438.	9438.	9438.	9438.	9438.
LESS.DEPRECIATN & AMORTIZTN	0.	0.	6746.	20238.	33729.	47221.	60713.	74205.	87697.
LIABILITIES	30439.	81170.	108566.	109931.	103544.	94560.	82781.	69533.	58939.
CURRENT LIABILITIES	0.	0.	5672.	15154.	19361.	20971.	19785.	17131.	17131.
ACCOUNTS PAYABLE	0.	0.	2628.	5132.	5589.	6080.	6537.	6537.	6537.
INCOME TAX PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.
DIVIDENDS PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.	0.
CURRENT PORTION OF DEBT									
LONG TERM DEBT	0.	0.	3044.	8117.	10594.	10594.	10594.	10594.	10594.
SHORT TERM DEBT	0.	0.	0.	1905.	3177.	4297.	2654.	0.	0.
FIXED LIABILITIES	30439.	81170.	102894.	94777.	84183.	73590.	62996.	52402.	41808.
LONG TERM DEBT BALANCE	30439.	81170.	102894.	94777.	84183.	73590.	62996.	52402.	41808.
STOCK HOLDERS EQUITY	10146.	27057.	29955.	21967.	16083.	12882.	12390.	12959.	14721.
SHARE CAPITAL	10146.	27057.	33821.	33821.	33821.	33821.	33821.	33821.	33821.
RETAINED ERNINGS	0.	0.	-3866.	-11854.	-17738.	-20939.	-21431.	-20862.	-19100.

	1992	1993	1994	1995	1996	1997	1998	1999
ASSETS	65675.	58538.	52249.	53687.	65837.	83563.	103914.	124265.
CURRENT ASSETS	31580.	37934.	45137.	53321.	65471.	83197.	103548.	123899.
CASH	17517.	23872.	31074.	39258.	51408.	69134.	89485.	109836.
ACCOUNTS RECEIVABLE	10538.	10538.	10538.	10538.	10538.	10538.	10538.	10538.
INVENTORIES								
PRODUCTS	3165.	3165.	3165.	3165.	3165.	3165.	3165.	3165.
MATERIALS	360.	360.	360.	360.	360.	360.	360.	360.
NET FIXED ASSETS	34096.	20604.	7112.	366.	366.	366.	366.	366.
INVESTMENT	135284.	135284.	135284.	135284.	135284.	135284.	135284.	135284.
LAND & SITE IMPROVEMENT	366.	366.	366.	366.	366.	366.	366.	366.
CONSTRUCTED FACILITIES	118698.	118698.	118698.	118698.	118698.	118698.	118698.	118698.
PRE-INVEST. & START-UP EXP	6782.	6782.	6782.	6782.	6782.	6782.	6782.	6782.
INTEREST DURING CONSTRUCTN	9438.	9438.	9438.	9438.	9438.	9438.	9438.	9438.
LESS.DEPRECIATN & AMORTIZTN	101188.	114680.	128172.	134918.	134918.	134918.	134918.	134918.
LIABILITIES	48345.	37752.	27158.	16564.	9014.	6537.	6537.	6537.
CURRENT LIABILITIES	17131.	17131.	17131.	14087.	9014.	6537.	6537.	6537.
ACCOUNTS PAYABLE	6537.	6537.	6537.	6537.	6537.	6537.	6537.	6537.
INCOME TAX PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.
DIVIDENDS PAYABLE	0.	0.	0.	0.	0.	0.	0.	0.
CURRENT PORTION OF DEBT								
LONG TERM DEBT	10594.	10594.	10594.	7550.	2477.	0.	0.	0.
SHORT TERM DEBT	0.	0.	0.	0.	0.	0.	0.	0.
FIXED LIABILITIES	31214.	20620.	10027.	2477.	0.	0.	0.	0.
LONG TERM DEBT BALANCE	31214.	20620.	10027.	2477.	0.	0.	0.	0.
STOCK HOLDERS EQUITY	17330.	20787.	25091.	37123.	56823.	77025.	97376.	117728.
SHARE CAPITAL	33821.	33821.	33821.	33821.	33821.	33821.	33821.	33821.
RETAINED ERNINGS	-16491.	-13034.	-8730.	3302.	23002.	43204.	63555.	83907.

*** THAI VCM PROJECT ***
PRODUCTION AND SALES PLAN
- BASE CASE -
(US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CAPACITY (VCM)	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.
CAPACITY UTILIZATION	0.402	0.785	0.855	0.930	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PRODUCTION (VCM)	32160.	62800.	68400.	74400.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.
INCREASE IN INVENTORY	3360.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME (VCM)	28800.	62800.	68400.	74400.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.
UNIT PRICE (VCM)	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500	0.7500
SALES REVENUE	21600.	47100.	51300.	55800.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.	60000.
CAPACITY (SODA)	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.
CAPACITY UTILIZATION	0.402	0.785	0.855	0.930	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PRODUCTION (SODA)	20743.	40506.	44118.	47988.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.
INCREASE IN INVENTORY	2167.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SALES VOLUME (SODA)	18576.	40506.	44118.	47988.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.	51600.
UNIT PRICE (SODA)	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500	0.3500
SALES REVENUE	6502.	14177.	15441.	16796.	18060.	18060.	18060.	18060.	18060.	18060.	18060.	18060.	18060.	18060.	18060.
*** TOTAL SALES REVENUE ***	28102.	61277.	66741.	72596.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.	78060.
*** TOTAL SALES VOLUME ***	47376.	103306.	112518.	122388.	131600.	131600.	131600.	131600.	131600.	131600.	131600.	131600.	131600.	131600.	131600.
*** AVERAGE SALES PRICE ***	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932	0.5932

*** THAI VCM PROJECT ***
PRODUCTION COST STATEMENTS
- BASE CASE -

(US$ 1000)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
PRODUCTION (VCM)	32160.	62800.	68400.	74400.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.	80000.
RAW SALT	805.	1572.	1712.	1862.	2002.	2002.	2002.	2002.	2002.	2002.	2002.	2002.	2002.	2002.	2002.
ETHYLENE	12221.	23864.	25992.	28272.	30400.	30400.	30400.	30400.	30400.	30400.	30400.	30400.	30400.	30400.	30400.
O2	642.	1253.	1365.	1484.	1596.	1596.	1596.	1596.	1596.	1596.	1596.	1596.	1596.	1596.	1596.
CHEMICALS	511.	998.	1087.	1182.	1271.	1271.	1271.	1271.	1271.	1271.	1271.	1271.	1271.	1271.	1271.
RAW MATERIAL COST	14178.	27686.	30155.	32800.	35269.	35269.	35269.	35269.	35269.	35269.	35269.	35269.	35269.	35269.	35269.
FUEL GAS	316.	617.	672.	731.	786.	786.	786.	786.	786.	786.	786.	786.	786.	786.	786.
POWER	3412.	6663.	7257.	7894.	8488.	8488.	8488.	8488.	8488.	8488.	8488.	8488.	8488.	8488.	8488.
STEAM (15K)	614.	1199.	1306.	1420.	1527.	1527.	1527.	1527.	1527.	1527.	1527.	1527.	1527.	1527.	1527.
STEAM (2K)	230.	448.	488.	531.	571.	571.	571.	571.	571.	571.	571.	571.	571.	571.	571.
FILTERED WATER	157.	307.	334.	364.	391.	391.	391.	391.	391.	391.	391.	391.	391.	391.	391.
DMW	83.	162.	177.	193.	207.	207.	207.	207.	207.	207.	207.	207.	207.	207.	207.
PORTABLE WATER	18.	35.	38.	42.	45.	45.	45.	45.	45.	45.	45.	45.	45.	45.	45.
INSTR/PLANT AIR	158.	308.	335.	365.	392.	392.	392.	392.	392.	392.	392.	392.	392.	392.	392.
N2	134.	262.	286.	311.	334.	334.	334.	334.	334.	334.	334.	334.	334.	334.	334.
UTILITIES COST	5122.	10002.	10894.	11849.	12741.	12741.	12741.	12741.	12741.	12741.	12741.	12741.	12741.	12741.	12741.
WASTE WATER TREATMENT	167.	326.	355.	386.	415.	415.	415.	415.	415.	415.	415.	415.	415.	415.	415.
VARIABLE COST	19467.	38014.	41403.	45035.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.	48425.
DEPRECIATION (PROCESS PLANT)	5935.	11870.	11870.	11870.	11870.	11870.	11870.	11870.	11870.	11870.	5935.	0.	0.	0.	0.
DEPRECIATION (PRE-INVEST)	339.	678.	678.	678.	678.	678.	678.	678.	678.	678.	339.	0.	0.	0.	0.
DEPRECIATION (INTEREST DUR.)	472.	944.	944.	944.	944.	944.	944.	944.	944.	944.	472.	0.	0.	0.	0.
DEPRECIATION	6746.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	6746.	0.	0.	0.	0.
AMORTIZATION	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
DEPRECIATION & AMORTIZATION	6746.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	13492.	6746.	0.	0.	0.	0.
LABOUR COST	397.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.
OVERHEAD	397.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.	794.
EMPLOYMENT COST	794.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.	1588.
MAINTENANCE COST	1780.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.	3561.
ELECTRODE & IEM	612.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.	1223.
TAX & INSURANCE	890.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.	1780.
DIRECT FIXED COST	4076.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.	8152.
EX-FACTORY PRODUCTION COST	30289.	59658.	63048.	66629.	70069.	70069.	70069.	70069.	70069.	70069.	63323.	56577.	56577.	56577.	56577.
UNIT DIRECT OPERATING COST	0.9418	0.9500	0.9217	0.8962	0.8759	0.8759	0.8759	0.8759	0.8759	0.8759	0.7915	0.7072	0.7072	0.7072	0.7072
ADMINISTRATIVE & SALES EXP.	606.	1193.	1261.	1334.	1401.	1401.	1401.	1401.	1401.	1401.	1266.	1132.	1132.	1132.	1132.
INTEREST ON LOAN NO.1	1218.	2374.	2131.	1887.	1644.	1400.	1157.	913.	670.	426.	183.	0.	0.	0.	0.
INTEREST ON LOAN NO.2	2029.	4059.	3957.	3551.	3145.	2740.	2334.	1928.	1522.	1116.	710.	304.	0.	0.	0.
INTEREST ON LOAN NO.3	812.	1623.	1623.	1583.	1420.	1258.	1096.	933.	771.	609.	446.	284.	122.	0.	0.
INTEREST ON LOAN NO.4	179.	356.	358.	349.	313.	277.	242.	206.	170.	134.	98.	63.	27.	0.	0.
INTEREST ON LONG-TERM DEBT	4238.	8414.	8069.	7370.	6523.	5675.	4828.	3980.	3133.	2285.	1438.	651.	149.	0.	0.
INTEREST ON SHORT-TERM DEBT	0.	0.	248.	413.	559.	345.	0.	0.	0.	0.	0.	0.	0.	0.	0.
TOTAL PRODUCTION COST	35132.	69265.	72625.	75796.	78552.	77491.	76298.	75451.	74603.	73756.	66028.	58360.	57858.	57709.	57709.
UNIT PRODUCTION COST	1.0924	1.1029	1.0618	1.0188	0.9819	0.9686	0.9537	0.9431	0.9325	0.9219	0.8253	0.7295	0.7232	0.7214	0.7214

*** THAI VCM PROJECT ***
IRR CALCULATION ON TOTAL INVESTMENT
- BASE CASE - (US$ 1000)

YEAR	TOTAL INVESTMENT	PROFIT BEFORE TAX	DEPRECIATN	INTEREST ON L-T DEBT	RETURN BEFORE TAX	DISCOUNT FACTOR	(BEFORE TAX) PRESENT VALUE INVEST.	(BEFORE TAX) PRESENT VALUE RETURN	(LESS) INCOME TAX	RETURN AFTER TAX	DISCOUNT FACTOR	(AFTER TAX) PRESENT VALUE INVEST.	(AFTER TAX) PRESENT VALUE RETURN
1983	37332.	0.	0.	0.	0.	1.0000	37332.	0.	0.	0.	1.0000	37332.	0.
1984	61384.	0.	0.	0.	0.	0.9084	55763.	0.	0.	0.	0.9084	55763.	0.
1985	31606.	-3866.	6746.	4238.	7117.	0.8253	26083.	5874.	0.	7117.	0.8253	26083.	5874.
1986	0.	-7988.	13492.	8414.	13918.	0.7497	0.	10434.	0.	13918.	0.7497	0.	10434.
1987	0.	-5884.	13492.	8069.	15677.	0.6811	0.	10677.	0.	15677.	0.6811	0.	10677.
1988	0.	-3201.	13492.	7370.	17661.	0.6187	0.	10927.	0.	17661.	0.6187	0.	10927.
1989	0.	-492.	13492.	6523.	19523.	0.5620	0.	10973.	0.	19523.	0.5620	0.	10973.
1990	0.	569.	13492.	5675.	19736.	0.5106	0.	10077.	0.	19736.	0.5106	0.	10077.
1991	0.	1762.	13492.	4828.	20081.	0.4638	0.	9314.	0.	20081.	0.4638	0.	9314.
1992	0.	2609.	13492.	3980.	20081.	0.4214	0.	8461.	0.	20081.	0.4214	0.	8461.
1993	0.	3457.	13492.	3133.	20081.	0.3828	0.	7687.	0.	20081.	0.3828	0.	7687.
1994	0.	4304.	13492.	2285.	20081.	0.3477	0.	6983.	0.	20081.	0.3477	0.	6983.
1995	0.	12032.	6746.	1438.	20216.	0.3159	0.	6386.	0.	20216.	0.3159	0.	6386.
1996	0.	19700.	0.	651.	20351.	0.2870	0.	5840.	0.	20351.	0.2870	0.	5840.
1997	0.	20202.	0.	149.	20351.	0.2607	0.	5305.	0.	20351.	0.2607	0.	5305.
1998	0.	20351.	0.	0.	20351.	0.2368	0.	4820.	0.	20351.	0.2368	0.	4820.
1999	-4841.	20351.	0.	0.	20351.	0.2151	-1042.	4378.	0.	20351.	0.2151	-1042.	4378.
TOTAL	125480.				275577.		118136.	118136.		275577.		118136.	118136.

***** INTERNAL RATE OF RETURN ***** 10.08 PER CENT (BEFORE TAX) 10.08 PER CENT (AFTER TAX)

***** PAY-OUT PERIOD ***** 8.30 YEAR (BEFORE TAX) 8.30 YEAR (AFTER TAX)
(THE YEAR WHEN THE TOTAL CAPITAL COST WILL BE PAID OUT BY ACCUMULATED TOTAL RETURN, FROM THE BEG. OF OPERATION)

CAPITAL REQUIREMENTS	
LAND	366.
CONSTRUCTED FACILITIES	118698.
PRE-INVEST AND START-UP EXP	6782.
INTEREST DURING CONSTRUCTION	9438.
TOTAL FIXED CAPITAL	135284.
INITIAL WORKING CAPITAL	4475.
TOTAL CAPITAL COST	139759.

SOURCE OF FUNDS	
PAID-UP SHARE CAPITAL	33821.
LONG TERM DEBT	105938.
SHORT TERM DEBT	0.
FINANCIAL RESOURCES	139759.

*** THAI VCM PROJECT ***
PROFITABILITY AND FINANCIAL INDICATORS
- BASE CASE - (US$ 1000)

YEAR	(1) AFT TAX PROFIT -TO- SALES REV (PCT)	(2) AFT TAX PROFIT -TO- S/H EQUITY (PCT)	(3) BFR TAX PRCFIT -TC- INVESTMNT (PCT)	(4) AFT TAX PROFIT -TO- S/CAPITAL (PCT)	(5) CURRENT RATIO	(6) QUICK RATIO	(7) DEBT SERVICE RATIO	(8) L/T DEBT -TO- S/H EQUITY	(9)* PROFIT B.E.P. CAPACITY UTILIZE (PCT)	(10)* CASH B.E.P. SALES PRICE (PRICE)	(11)* CASH B.E.P. CAPACITY UTILIZE (PCT)
1985	-13.8	-12.9	-2.8	-11.4	1.76	1.18	1.68	77./ 23.	53.5	985.6	29.6
1986	-13.0	-36.4	-5.7	-23.6	1.11	0.88	1.21	81./ 19.	106.9	936.6	69.8
1987	-8.8	-36.6	-4.2	-17.4	0.93	0.75	0.97	84./ 16.	106.4	983.2	87.3
1988	-4.4	-24.8	-2.3	-9.5	0.92	0.76	0.98	85./ 15.	104.3	979.8	94.1
1989	-0.6	-4.0	-0.4	-1.5	1.04	0.86	1.14	84./ 16.	101.7	945.7	91.5
1990	0.7	4.4	0.4	1.7	1.25	1.04	1.21	80./ 20.	98.0	932.4	87.7
1991	2.3	12.0	1.3	5.2	1.52	1.32	1.30	74./ 26.	93.8	917.5	83.5
1992	3.3	15.1	1.9	7.7	1.84	1.64	1.38	64./ 36.	90.8	906.9	80.5
1993	4.4	16.6	2.5	10.2	2.21	2.01	1.46	50./ 50.	87.8	896.3	77.5
1994	5.5	17.2	3.1	12.7	2.63	2.43	1.56	29./ 71.	84.8	885.7	74.5
1995	15.4	32.4	8.6	35.6	3.79	3.53	1.68	6./ 94.	57.6	873.4	71.1
1996	25.2	34.7	14.1	58.2	7.26	6.87	2.48	0./100.	30.9	823.9	57.4
1997	25.9	26.2	14.5	59.7	12.73	12.19	7.75	0./100.	29.1	754.2	37.8
1998	26.1	20.9	14.6	60.2	15.84	15.30	**********	0./100.	28.6	721.4	28.6
1999	26.1	17.3	14.6	60.2	18.95	18.41	**********	0./100.	28.6	721.4	28.6
AVERAGE1	6.3	5.5	4.0	16.5	4.92	4.61	**********	48./ 52.	73.5	884.3	66.6
AVERAGE2	7.7	14.7	4.0	16.5	3.23	2.98	1.69	50./ 50.			

(AVERAGE1) : SUM OF ANNUAL FIGURES OF PERCENTAGE AND RATIO IS DIVIDED BY NO. OF YEARS(SIMPLE AVERAGE)
(AVERAGE2) : AVERAGE FIGURES ARE CALCULATED BY ACTUAL VALUES ACCUMULATED OVER THE PROJECT LIFE(WEIGHTED AVERAGE)
* NOTE FOR (9)(10)(11)
WHEN THERE ARE TWO OR MORE PRODUCTS, AND DURING THE YEARS WHEN ALL OF PRODUCTS ARE NOT PRODUCED AT THE SAME RATE OF CAPACITY UTILIZATION, ABOVE BREAK-EVEN-POINTS CANNOT GIVE CORRECT FIGURES.

PART VIII ECONOMIC EVALUATION

PART VIII ECONOMIC EVALUATION

CHAPTER 1 INTRODUCTION

This part of the report evaluates the project in terms of its contribution to the Thai economy. The major contributions which the project would make to the Thai economy are:

(1) By means of production of ethylene from ethane, and the realization of downstream projects utilizing that ethylene, the value added of the ethane fraction of natural gas resources present in the Bay of Siam will be enhanced, and

(2) By producing ethylene and VCM in Thailand, a contribution would be made to the foreign exchange balance of the country and, also, there would be favorable impact on related industries.

In the following chapters, the economic costs and benefits of this project are analyzed, and on the basis of that the economic internal rate of return is calculated, and the project is evaluated by quantitative means from the viewpoint of the national economy.

CHAPTER 2 ECONOMIC EVALUATION OF THE ETHYLENE PROJECT

2–1 ECONOMIC BENEFITS OF THE ETHYLENE PROJECT

Economic benefits to be obtained through realization of the ethylene project comprise direct benefits and indirect benefits.

2–1–1 Direct benefits

The direct benefits can be evaluated as representing the economic value of ethylene produced through investment in this project. As is discussed in Part II, it is thought to be necessary to lower the price of ethylene to about US$500/t (constant 1980 price) in order to obtain an ethylene price which is competitive[1)] in comparison with importing ethylene derivatives such as LDPE and HDPE from the international market. Therefore, this price is used in the economic evaluation of the ethylene project[2)] and for calculation of the economic internal rate of return as given below. This ethylene clearly has the nature of being an import substitute, so a shadow exchange rate is applied[3)].

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1) In this case the customs tariff applied to imports such as LDPE and HDPE is excluded, as a transferable cost, because economic evaluation is to be performed. Therefore in order to compete with imported LDPE and HDPE, where in the preceding Part VII which is concerned with financial evaluation the ethylene price is set at US$800/t, including in the import price of polyethylenes including customs tariff, in the economic evaluation in this part of the study, this tariff is deducted and the cost of about US$500/t is used as the ethylene price.

2) At about 20 km east of the proposed site for the ethylene plant in Rayong, a LDPE plant which is to use imported ethylene as feedstock is being constructed and parallel to that a jetty, required for the importation of ethylene, and a low-temperature liquefied ethylene storage tank, are also under construction. This LDPE plant has recourse to the use of imported ethylene if the proposed ethylene plant is not constructed, and at least until the time of completion of construction of the ethylene plant, it will be necessary to rely on imports. It is to be expected that when ethylene is purchased in the international market, judging from current Japanese business transactions, the cost would be on the order of US$800/t as the FOB price, plus US$140/t for freight, for a Thai CIF price of US$940/t. There would not be a great difference even if the ethylene is imported from some other country. Therefore when comparison is made here of importing ethylene derivatives such as HDPE and LDPE from international market sources, this ethylene price is relatively high. Although it is necessary to take this into consideration in the course of economic analysis, a conservative view has been taken here, and US$500/t has been adopted as the price of ethylene.

3) According to the ADB's "Report on the feasibility of a rock salt – soda ash project in Thailand," Vol. 4 (Sept. 6, 1978) the standard conversion factor is 0.791. Therefore the shadow exchange rate is (official exchange rate, Baht/US$)/(0.791).

2–1–2 Indirect benefits

The following are the indirect benefits to be gained from implementation of this project.

(1) Creation of employment opportunities

Employment opportunities would be created during the construction of the plants and facilities, and for their operation.

(2) Impact on related industries

The project will exert good influence on related industries in Thailand such as engineering, civil and construction and transportation industries, etc.

(3) Contribution to the development of the regional economy

Directly and indirectly this project will contribute to the development of the economy of the Rayong district, and to the diversification of Thai industry in particular.

Implementation of this project would provide various indirect benefits to the Thai nation, but it is difficult to quantify those benefits. Therefore, in the calculation of the economic internal rate of return, these indirect benefits are not included.

2–2 ECONOMIC COSTS

Economic costs of the project are as follows.

(1) Initial costs (capital costs) essential for the realization of the project.

(2) Ethane fraction in natural gas consumed in the production of ethylene (ethane to be separated in the gas processing plant)

(3) Labor expended.

(4) Other costs necessary for ethylene to be produced.

(1) Initial project costs

Included in the initial cost[1] necessary to realize this project are the ethylene plant cost, pre-operation costs, initial operation costs, and working capital. For the foreign exchange portion of these costs, the shadow exchange rate is applied.

(2) The economic cost of ethane

The economic cost of ethane may be considered to be the opportunity cost of ethane in the absence of this ethylene project. Prior to the undertaking of this feasibility study, it had been determined with regard to the gas processing plant that there would be an 84% recovery rate for ethane[2] and on the basis of this recovery 290,000 t/y of ethane is anticipated.

Whether or not ethane is separated from the gas processing plant, if the ethylene project were not to be realized in Thailand, it would be necessary to evaluate it as having the same value, on a calorie base, as heavy oil for use as power generation fuel, because there is no use for it other than as fuel.

In order to obtain the economic cost of ethane, it would be necessary to add the operating costs at the gas processing plant which are necessary to recover the ethane[3], to the ethane price in terms of heavy oil equivalent.[4]

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1) It is necessary to exclude taxes and duties levied within Thailand as a transferable cost, but because capital cost estimate in Tables VI-1 and VI-2 do not include any taxes and duties, no such necessity exists in this particular case.

2) According to PTT.

3) On other words, the case when the gas processing plant is operated with recovery of ethane, and the case when it is operated without recovery of ethane, are compared, and the difference is used. The types and capacity of the facilities and equipment to be included in the gas processing plant have already been determined and if construction proceeds along the lines indicated by the facilities plan, it will be possible to exclude the fixed cost which otherwise cover the cost of ethane.

4) As has already been explained, this is taken as US$25.5/bbl (at constant 1980 prices), and with this equal to ethane in terms of calorific value base, conversion of ethane cost would be US$190/t.

When the gas processing plant which is now being planned commences operation in the future, in comparison to the situation wherein ethane is not recovered, the cost of operation when it is recovered would be somewhat higher (because fixed costs are thought to be the same in either case, almost the entire difference represents additional energy cost), so the inquiry cannot be accomplished without data now being studied by PTT. Nevertheless, it is thought that in any event the larger share of equipment and power costs at the gas processing plant are to be for the separation of carbon dioxide from the natural gas, and that this must be separated from the gas whether or not there is a use for it and whether ethane is recovered or not in the same plant, the difference in power cost will not be great. Final resolution of this problem must be held in abeyance until detailed data are made available [1]. It is therefore, assumed that for the economic analysis undertaken in this feasibility study this cost increment is taken to be US$50/t ethane [2], which is added to the US$190/t to obtain US$240/t as the economic cost of ethane for use in calculation of the economic internal rate of return.

(3) Labor cost

Labor cost is calculated by use of the conversion factor 0.963. [3]

(4) Other production cost items

The shadow exchange rate is used for other materials provided through other than local supply, such as catalyst, chemical, etc.

2–3 ECONOMIC INTERNAL RATE OF RETURN

On the basis of the above-cited economic benefits and costs, the economic internal rate of return has been calculated. Results are given in Table VIII-1. The rate is 18.1% which approaches the financial internal rate of return previously calculated. [4] Therefore, this project is judged viable in economic terms.

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1) Required data comprise the breakdown of the gas processing plant cost, the energy balance for the major units in the plant, and so on.

2) Based on the study team's experience.

3) According to the above-cited ADB report. It is more reasonable to use current actual wages than shadow wages for this project because it requires, on the whole, highly skilled labor. Because the conversion factor is almost 1, however it is used here.

4) As has already been noted, because of the nature of PTT, import taxes on plant equipment are to be waived, and there is no need to take income tax into account in balance sheet calculations, so that the financial IRR and the economic IRR are expected to be similar.

Table VIII–1 ECONOMIC INTERNAL RATE OF RETURN
– PTT ETHYLENE PROJECT –

(Unit: Million Baht)

Year	Economic Cost			Economic Benefit	Discount Factor (at 18.1%)	Present Value (Discount Rate = 0.181)	
	Capital Cost	Operating Cost	Total			Economic Cost	Economic Benefit
1982	707		707		1.0000	707	
1983	1,607		1,607		0.8466	1,360	
1984	1,644		1,644		0.7167	1,178	
1985	877	454	1,341	868	0.6067	814	527
1986		994	994	1,849	0.5137	511	950
1987		1,026	1,026	1,940	0.4349	446	844
1988		1,139	1,139	2,211	0.3681	419	814
1989		1,200	1,200	2,366	0.3117	374	737
1990		1,240	1,240	2,454	0.2638	327	647
1991		1,298	1,298	2,583	0.2234	290	577
1992		1,339	1,339	2,677	0.1891	253	506
1993		1,384	1,384	2,777	0.1601	222	445
1994		1,475	1,475	2,980	0.1355	200	404
1995		1,470	1,470	2,980	0.1147	169	342
1996		1,465	1,465	2,980	0.0971	142	289
1997		1,465	1,465	2,980	0.0822	120	245
1998		1,465	1,465	2,980	0.0696	102	207
1999		1,465	1,465	2,980	0.0589	79	176
Total						7,713 =	7,710

Note: Economic Internal Rate of Return = 18.1%

CHAPTER 3 ECONOMIC EVALUATION OF THE VCM PROJECT

3–1 ECONOMIC BENEFITS OF THE VCM PROJECT

As is explained in Part II, the price of VCM imported from the world market would be about US$600/t (1980 constant price). Similarly, the boundary price of caustic soda when it is imported from the world market is about US$300/t (1980 constant price).[1)] Therefore these prices are used to evaluate the economic price of VCM and caustic soda produced by the VCM plant.

Because there are import substitution effects (if VCM and caustic soda are not produced as part of this project, imports must be made in order to satisfy domestic demand) a shadow exchange rate is used for their prices.[2)]

For this project, as in the case of the ethylene project, indirect benefits may be expected through the creation of employment opportunities, impact on related industry, and contribution to the development of the regional economy, but because of the difficulty of quantitatively evaluating such benefits they are not included in the calculation of the economic internal rate of return.

3–2 ECONOMIC COSTS

(1) Initial project costs

The same as in the case for the ethylene project.

(2) Cost of ethylene and salt

The economic cost of ethylene for this project is taken to be the alternate opportunity cost of that ethylene. It is assumed that the ethylene would be supplied from the ethylene plant studied in other parts of this report. The alternate opportunity cost of that ethylene is thought to be based on the opportunity cost of ethane used to produce the ethylene. In other words, the opportunity cost of ethylene supplied to the VCM plant is thought to equal the sum of the opportunity cost of the ethane used to produce the ethylene, and the cost required for the conversion of ethane to ethylene in the ethylene plant. The economic cost of feedstock ethane supplied to the ethylene plant, or the opportunity cost in this case, is estimated to be US$240/t as stated in Chapter 2. The conversion cost of ethane to ethylene[3)]

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1) The same as for the ethylene project, in this case as well the import duty on products is excluded, as a transfer cost. Therefore, excluding import duty on VCM and caustic soda, the import price of VCM is US$600/t, and that of caustic soda is US$300/t.

2) Regarding the shadow exchange rate, refer to the discussion on the ethylene project in Section 2-1.

3) Difference between ethane cost and ethylene production cost.

will vary according to conditions including the rate of utilization of plant capacity, but the ethylene plant is here considered to have the average conversion cost of about US$200/t (see Part VII, Chapter 3). Therefore the economic cost of ethylene supplied to the VCM plant is calculated as follows.

US$240 x 1.25[1] + US$200 = US$500

In the economic analysis the economic cost of ethylene is therefore taken to be US$500/t.

With regard to crude salt, the price delivered to the plant, 450 Baht/t, is taken as the economic cost.

(3) Power cost

The charge for power supplied to the VCM plant by EGAT/PEA is 1.1 Baht/KWH; this is converted to the economic cost by use of the conversion factor for electricity, 1.276.[2]

(4) Labor cost

The same conversion factor for labor as is used for the ethylene plant, 0.936, is employed.

(5) Other cost components

For imported items such as chemicals, electrodes, ion exchange membranes etc., the shadow exchange rate is used to convert costs to local currency.

3–3 ECONOMIC INTERNAL RATE OF RETURN

On the basis of the foregoing economic benefits and costs the economic internal rate of return (EIRR) of the VCM plant has been calculated. Results are as shown in Table VIII-2: the EIRR is 13.8%. This rate of return can be said to signify that the project is desirable from the viewpoint of the national economy. On the basis of the calculation of the financial internal rate of return and the financial evaluation done in Part VII, the project is not necessarily attractive but because its implementation is fabourable in terms of the national economy, it is desirable that the Thai Government and PTT adopt measures in support of it.

1) To produce one ton of ethylene, 1.25t of ethane are required.

2) From the ADB report quoted above.

Table VIII–2 ECONOMIC INTERNAL RATE OF RETURN
–THAI VCM PROJECT–

(Unit: Million Baht)

Year	Economic Cost			Economic Benefit	Discount Factor (at 13.79%)	Present Value (at 13.79%)	
	Capital Cost	Operating Cost	Total			Economic Cost	Economic Benefit
1983	914		914		1.0000	914	
1984	1,506		1,506		0.8788	1,323	
1985	758	374	1,132	592	0.7723	874	457
1986		857	857	1,291	0.6787	582	876
1987		915	915	1,407	0.5965	546	839
1988		977	977	1,530	0.5242	512	802
1989		1,035	1,035	1,645	0.4607	477	758
1990		1,035	1,035	1,645	0.4048	419	666
1991		1,035	1,035	1,645	0.3558	368	585
1992		1,035	1,035	1,645	0.3127	324	514
1993		1,035	1,035	1,645	0.2748	284	452
1994		1,035	1,035	1,645	0.2415	250	397
1995		1,032	1,032	1,645	0.2122	219	349
1996		1,029	1,029	1,645	0.1865	192	307
1997		1,029	1,029	1,645	0.1639	169	270
1998		1,029	1,029	1,645	0.1440	148	237
1999	–108	1,029	921	1,645	0.1266	117	208
Total						7,718 =	7,717

Note: Economic Internal Rate of Return = 13.79%