Specifications of each component facility are studied on the basis of overall material balance and above mentioned factors as follows.

(1) On-site Facilities

1) Coal Gasification Plant

i) Process : Molten iron bath

ii) Total capacity : 474,600 Nm^3·Raw gas/h

iii) No. of trains : Six
(Four out of six are to be normally operated)

iv) Coal receiving : Coal bunker at plant gate

v) Total amount of coal to be dried
N.W. Banko coal (23.1% moisture at plant gate) : 437 t/h
or N. Sutan Jeriji coal (26.8% moisture at plant gate) : 512 t/h

vi) Coal to be sent to the boiler after drying to 15% moisture;
N.W. Banko coal : 126 t/h
or N. Suban Jeriji coal : 147 t/h

vii) Sub material receiving
a) Lime : from Truck at B/L
b) Scrap : ditto
c) FeAl : ditto

viii) Raw gas condition : 2.5 kg/cm^2·G, 32°C at B/L
(gas holder to be installed inside B/L to absorb fluctuation of the produced gas pressure)

ix) Cooling Water : The plant to have its own system

x) Condition of saturated steam to be sent to the boiler :
75 kg/cm^2G, 290°C

xi) Solid waste removal
a) Dust : by truck at B/L
b) Slag : ditto

2) Methanol Plant

i) Process : Conventional

ii) Total capacity : 1,500,000 t·Methanol/y

iii) No. of Trains : Three

iv) Raw gas : 474,600 Nm^3/h

v) Product Specification : Chemical grade (99.9% CH_3OH)

vi) By-product

a) Fuel gas : to be sent to the Coal Gasification Plant and to the boiler at 3.5 kg/cm^2G, 40°C.

b) CO_2 (Acid Gas) : to be partially sent to the Coal Gasification Plant at 15 kg/cm^2G, 32°C.

3) Air Separation Plant

i) Total capacity : 122,000 $Nm^3 \cdot O_2/h$
26,600 $Nm^3 \cdot N_2/h$

ii) Raw material
Air : 610,500 Nm^3/h

iii) No. of trains : Three

iv) Gas purity
Oxygen : 99.5%
Nitrogen : 98.0%

v) Gas pressure for sending
Oxygen : 15 kg/cm^2G
Nitrogen : 7 kg/cm^2G

4) Boiler and Electric Power Generation Plant

i) Boiler

a) Type : Fluidized bed combustion

b) Total capacity : 892 t·Steam/h
320 t·Steam superheating/h

c) No. of trains : Three

d) Steam condition

to turbine generator : 109 kg/cm^2G, 541°C

HP steam (superheated): 65 kg/cm^2G, 480°C

ii) Power Generator

a) Type : Condensing extraction turbine

b) Total capacity : 111,000 kW

c) No. of units : Three

d) Voltage : 11,000 V

e) Phase number : 3 phase

f) Frequency : 50 Hz

g) Steam extraction condition

High : 65 kg/cm^2G, 480°C

Low : 3.5 kg/cm^2G, 156°C

iii) Electricity distribution system

a) Receiving voltage : 11,000 V

b) Phase number : 3 phase

c) Frequency : 50 Hz

d) Discharge voltage : 11,000 V

3,300 V

e) Total capacity : 111,000 kW

5) Utility Facilities

i) Cooling water

a) Type : Forced draft cooling tower

b) Total capacity : 89,230 t/h

c) Make-up water : 2,680 t/h

d) No. of trains : Three

c) Supply/return temperature : 32°C/42°C

f) Supply pressure : 8 kg/cm^2·G

ii) Boiler feed water

a) Total capacity : 1,590 t/h

b) No. of trains : Three

c) Make-up water : 410 t/h

d) Supply pressure : Deareratоr head

iii) Industrial water

a) Total capacity : 3,475 t/h

b) No. of trains : Three

c) Supply pressure : 8 kg/cm^2·G

iv) Service water

a) Total capacity : 20 t/h

b) No. of trains : One

c) Supply pressure : 3 kg/cm^2·G

v) Instrument/service air

a) Total capacity : 9,000 Nm^3/h

b) No. of trains : Three

c) Dew point of instrument air : 0°C

d) Supply pressure : 7 kg/cm^2·G

vi) Waste water treatment

a) Category of waste water

Clean : Waste water which has no possibility of being contaminated by oil, methanol, etc.

Dirty : Waste water which may be contaminated by oil, methanol, etc.

b) Treatment capacity

Clean waste water 1,205 t/h

Dirty waste water 207 t/h

c) No. of trains : Two

d) Pond : to be provided in order to prevent methanol discharge in case of emergency troubles

6) Product Storage

i) Type : Dome roof tank

ii) Total capacity (See Section 11-2-3) : 45,000 kℓ

iii) No. of tanks : Three

(2) Off-site Facilities

1) Belt Conveyor

i) Route : From N.W. Banko to Desa Muara Enim

ii) Capacity : 620 t/h

iii) No. of conveyor line : One

iv) Overall length : 14.2 km

v) Coal receiving : Bunker hopper at the mining area

vi) Coal conveying : to the coal bunker of the Gasification plant

2) Product Pipeline

i) Route : From Desa Muara Enim to Pladju

ii) Methanol transportation capacity

Normal : 187.5 t/h

Maximum : 206 t/h

iii) No. of line : One

iv) Overall length : 200 km

v) Elevation difference between the plant and the shipping terminal : -50 m

3) Product Shipping Terminal

i) Location : Pladju

ii) Total storage capacity : 90,000 kℓ (See Section 11-2-3)

iii) Methanol shipping capacity

Normal : 280 t/h

Maximum : 310 t/h

4) Water Intake Facility

i) Location : *Lematang riverside*

ii) Total capacity : 3,475 t/h

iii) No. of trains

a) Pit : One

b) Pump : Three trains (600 t/h·pump × 2 pumps/train)

10-3-3 Plant Layout

An image of the plant location map and layout is shown in Fig. 10-3-5 and Fig. 10-3-6. According to this proposed layout, about 515,000 m^2 of the site area will be required. Since the exact location of the plant site is not decided in this study, the layout should be reviewed and modified in the final engineering stage, reflecting the actual site conditions and its surroundings.

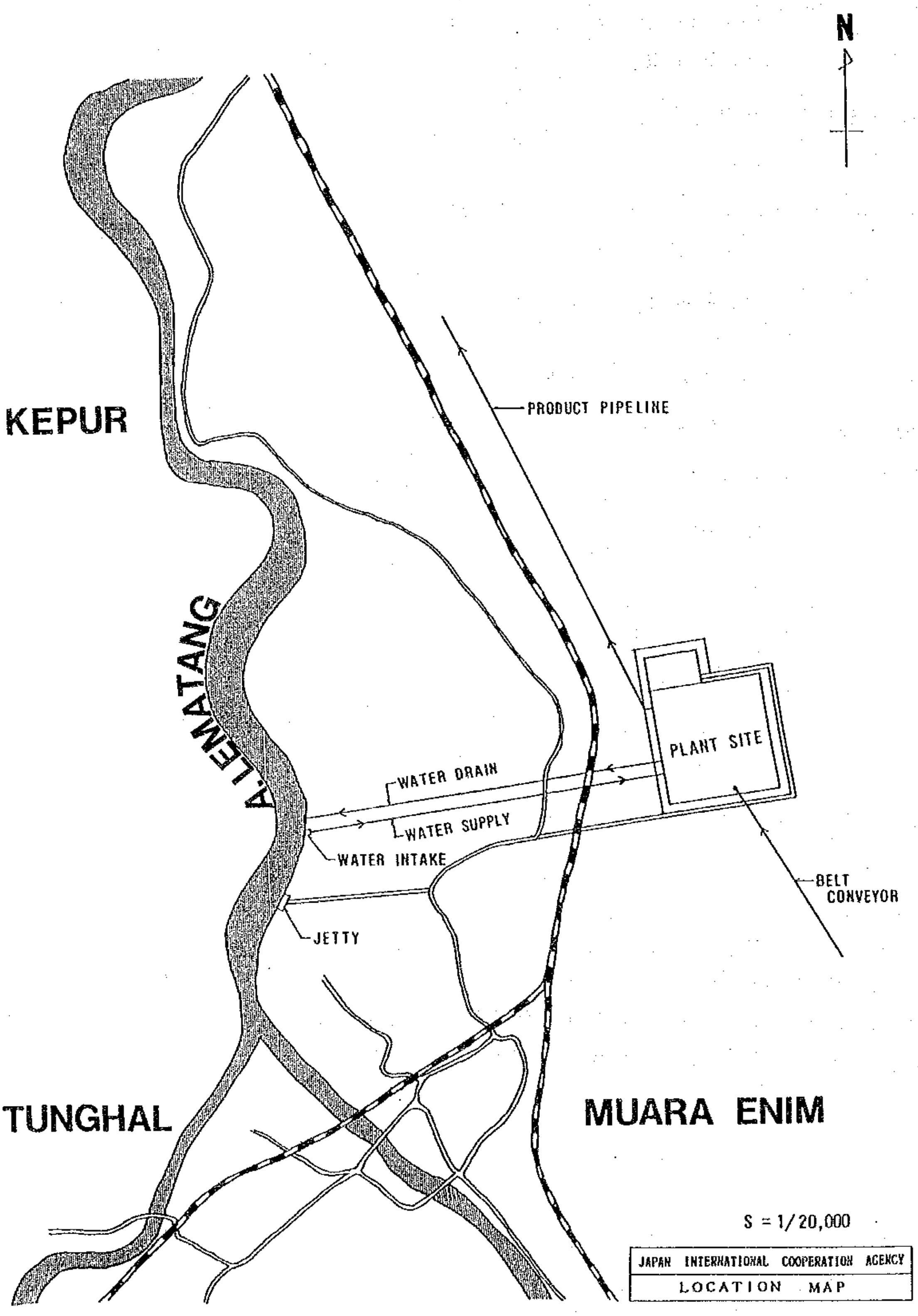


Fig. 10-3-5 Location Map

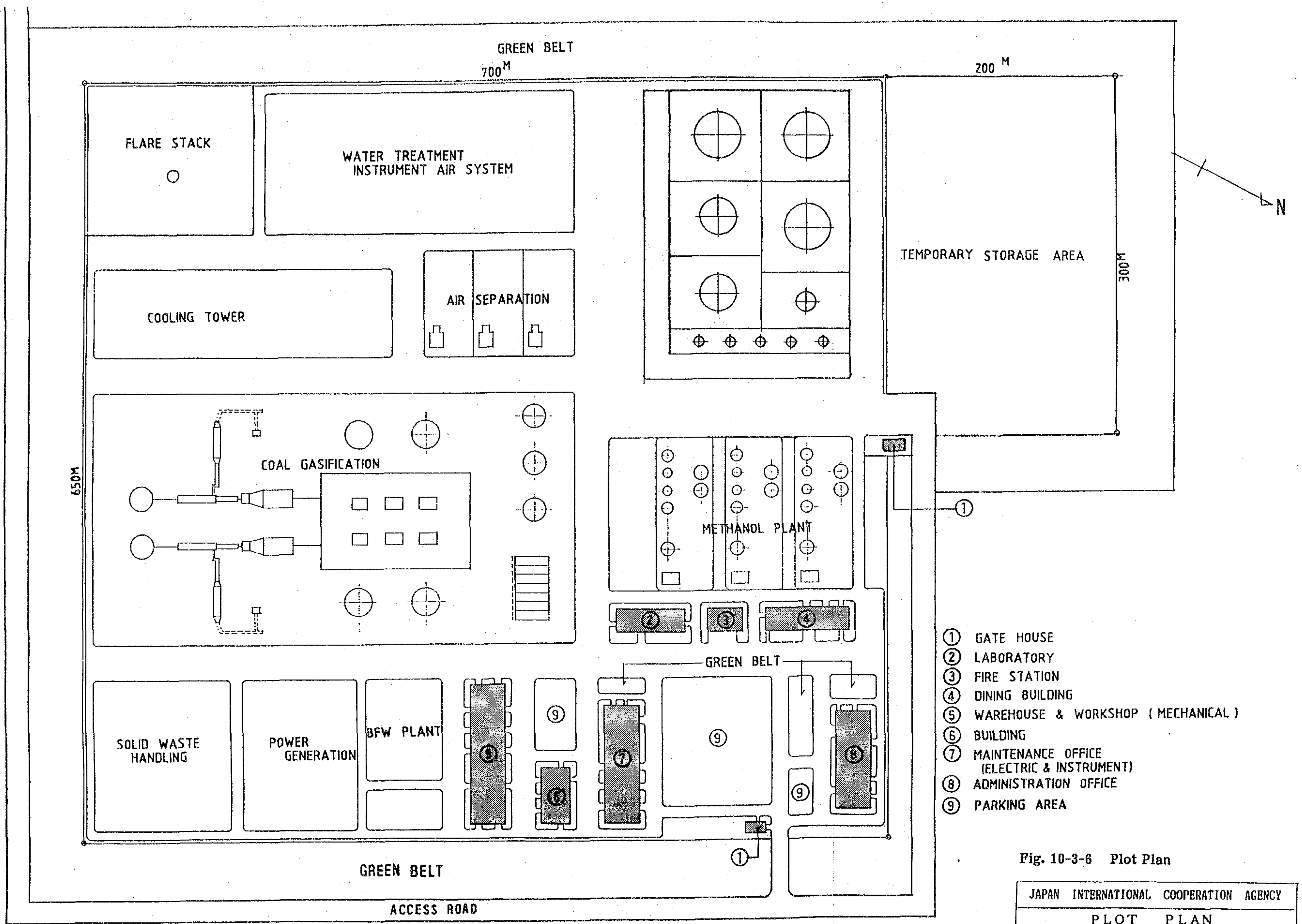


Fig. 10-3-6 Plot Plan

JAPAN INTERNATIONAL COOPERATION AGENCY
PLOT PLAN

10-3-4 Implementation Schedule of the Project

(1) Time Schedule of the Project Implementation

Table 10-3-3 shows the time schedule of the Project implementation.
It will need 11 years from the end of this feasibility study until the start of production.

(2) Construction Schedule of One Train

Construction schedule of one train is illustrated in Fig. 10-3-7.
It is considered in the study of construction schedule that:

1) Transportation of heavy equipment via Lematang river be scheduled for the rainy season.

2) Civil work be scheduled for the dry season as much as possible.

(3) Justification of Implementation Schedule

The justification of the Project implementation schedule mentioned in (1) has been investigated by referring to the Asahan Project as an example of a large scale project, and by investigating the consistency with the situation of fuel methanol market.

1) The Asahan Project

The Asahan Project, which consists of the construction of an aluminium smelter and hydropower plant utilizing Lake Toba's high location and big accumulation, is an informative example of a large scale project. The actual history of the Asahan Project is shown in Fig. 10-3-8.
After the feasibility study stage, actual implementation of the Ashan Project started in 1973 with the negotiation between the Asahan Technical Committee of Indonesia and Japanese Smelter companies on the actual development plan and basic matters of the project execution.
It took around 10 years until the smelter started partial operation in 1982.
Referring to the implementation record of the Asahan Project mentioned above, the Project implementation schedule of 11 years is considered to be reasonable.

2) Fuel Methanol Demand

According to the study in Chapter 5, the demand for fuel methanol in Indonesia will show a sharp increase in 2000. Therefore, the Project implementation plan to begin methanol production in 2000 is consistent with the demand forecast.

Summarizing 1) and 2) mentioned above, the Time Schedule proposed in (1) would be justified as a reasonable one.

Table 10-3-3 Time Schedule of the Project Implementation

Years	Period (Years)				Earliest Schedule
		Phase I	-	Feasibility Study Completed in FY 1988.	1988
0					
	2	Bridging I	-	Coordination for Entry into Phase II	1990
2					
	3	Phase II	-	Basic Design, Engineering, Final Feasibility Study	1993
5					
	2	Bridging II	-	Coordination for Entry into Phase III	1995
7					
	4	Phase III	-	Detail Design, Construction	1999
11					

Note: 1) In the period of Bridging I

A) To establish a consensus on whether or not to introduce fuel methanol into Indonesia if conditions are satisfied in the future.

B) To establish a consensus on how to finance, if conditions are satisfied in the future.

C) To establish responsible organizations for Phase II.

D) Assessment and decision on expenditures required for Phase II by responsible organizations.

2) In the period of Bridging II

A) To establish responsible organizations and management organizations for Phase III and operation.

B) To make a decision on the total investments.

C) To enter into a Financial contract

D) To enter into a sales/purchase contract.

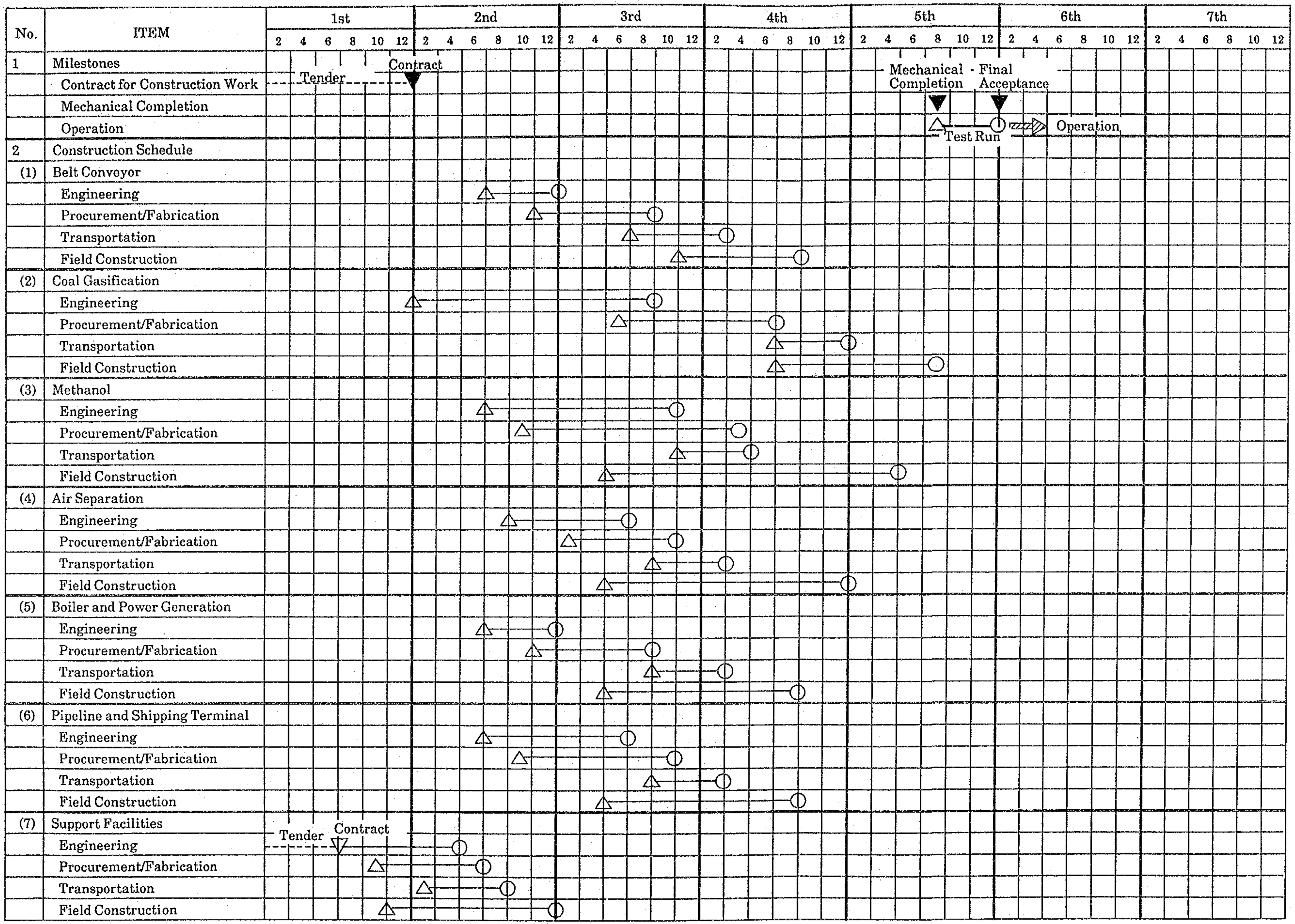


Fig. 10-3-7 Construction Schedule of One Train

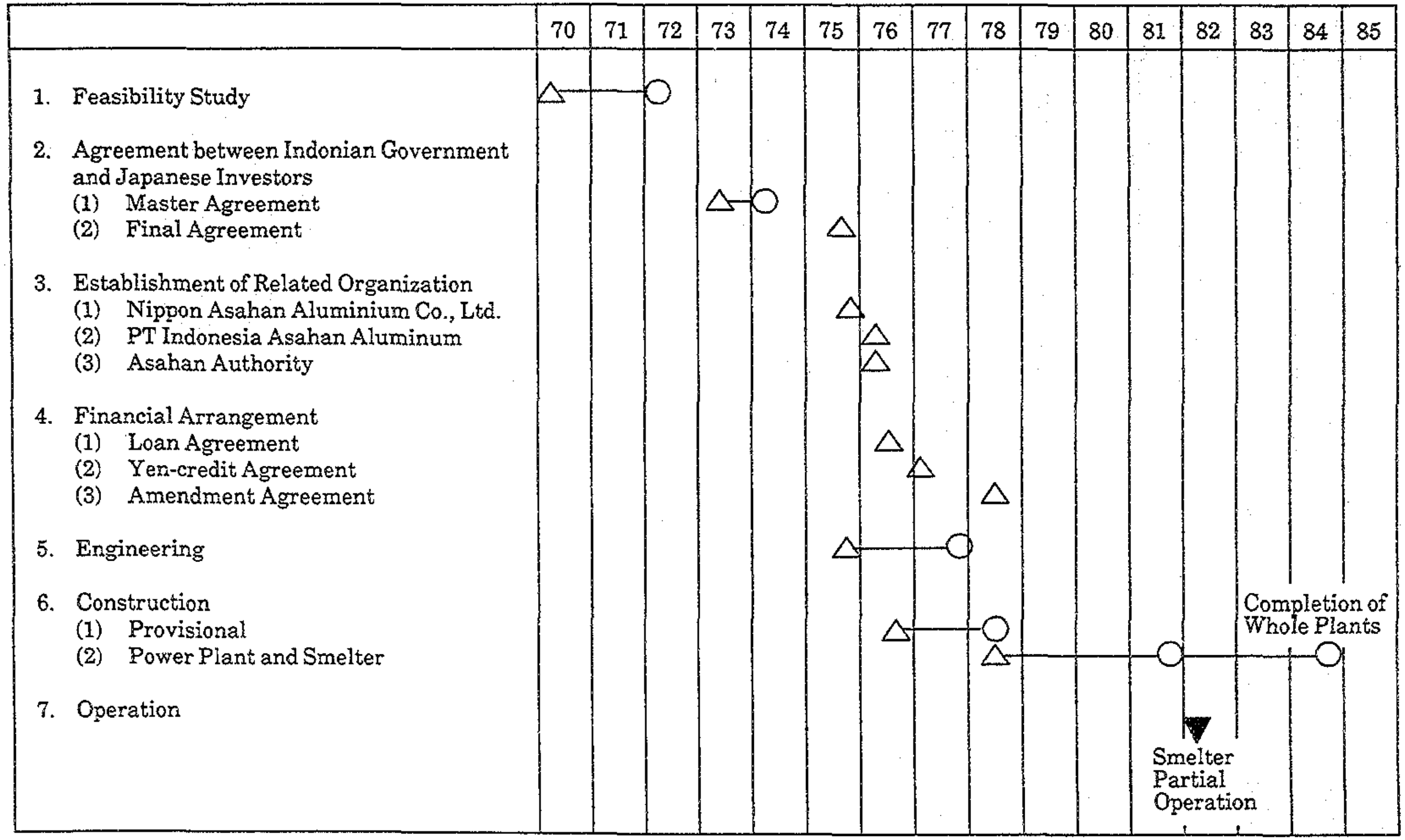


Fig. 10-3-8 History of the Asahan Project Implementation

10-3-5 Organization

Company organization strongly depends on management policy and should be decided after the responsible entity is set up. In this stage, proposed is a simple organization which unifies the functions of the headquarters and the factory, as shown in Fig. 10-3-9.

Though coal mine is out of the scope of this Study, it is proposed that the coal mining department should be included in a company for the effective management of the project implementation.

Note: The financial analysis should be carried out on the basis of plant gate coal cost.

Based on the organization mentioned above, a personnel plan has been studied and is summarized in Table 10-3-4.

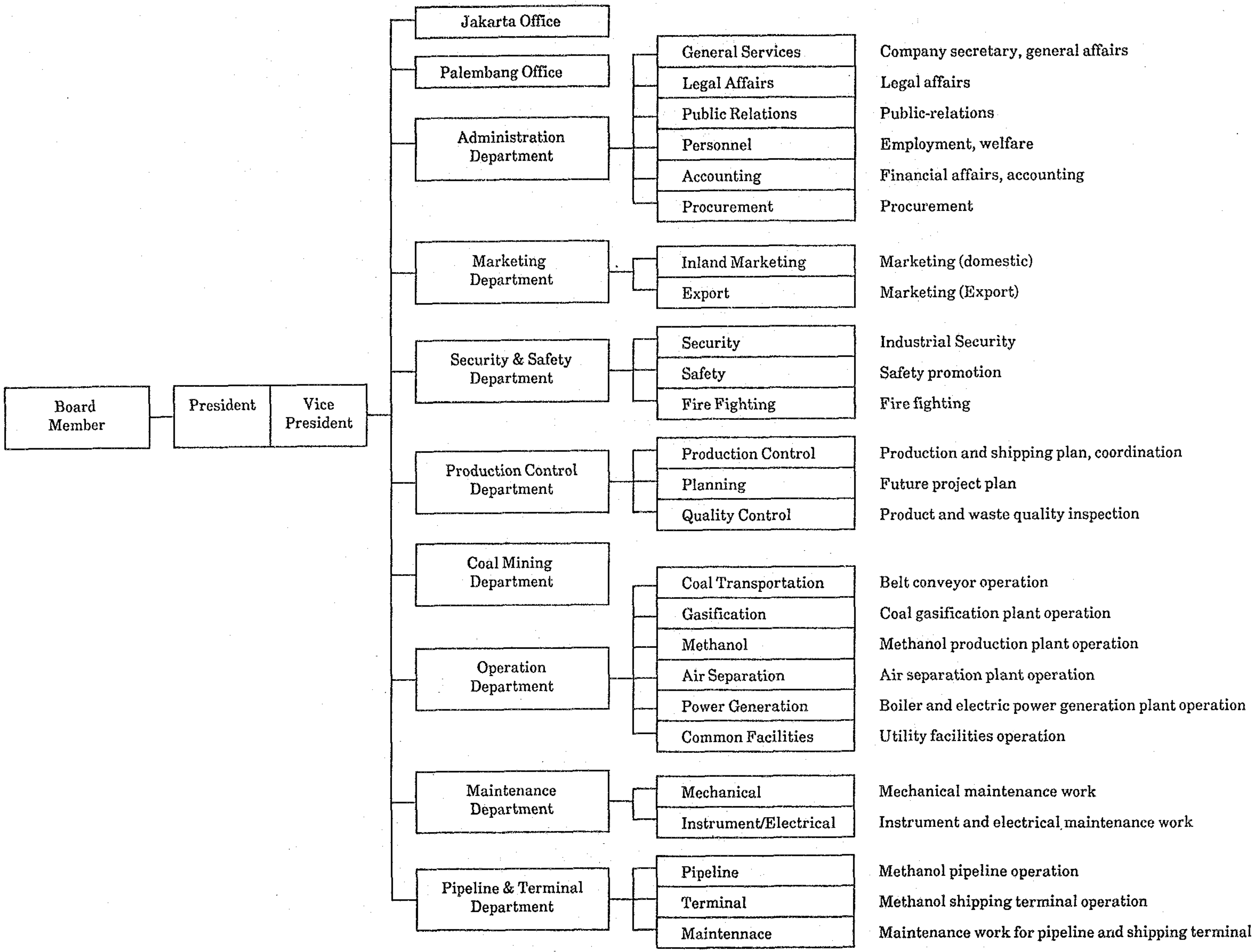


Fig. 10-3-9 Overview of the Company Organization

Table 10-3-4 Personnel Plan (Coal Mining Department is not included)

DEPARTMENT	SECTION	2000 (1st Train start)								2003 (2nd Train start)								2005 (3rd Train start)							
		G	M	A	E	F	O	S	Total	G	M	A	E	F	O	S	Total	G	M	A	E	F	O	S	Total
Jakarta Office		0	1	1	2	4	2	0	10	0	1	1	2	4	2	0	10	0	1	1	2	4	2	0	10
Palembang Office		0	1	1	2	4	2	0	10	0	1	1	2	4	2	0	10	0	1	1	2	4	2	0	10
	General Services	1	1	3	4	7	84	0	100	1	1	3	4	7	94	0	110	1	1	3	4	7	104	0	120
Administration	Legal Affairs		1	1	2	1	1	0	6		1	1	2	1	1	0	6		1	1	2	1	1	0	6
	Public Relations		1	1	1	2	2	0	7		1	1	1	2	2	0	7		1	1	1	2	2	0	7
	Personnel		1	3	6	8	4	0	22		1	3	6	8	4	0	22		1	3	6	8	4	0	22
	Accounting		1	3	6	9	5	0	24		1	3	6	9	5	0	24		1	3	6	9	5	0	24
	Procurement		1	1	2	3	4	0	11		1	1	2	3	4	0	11		1	1	2	3	4	0	11
	(Subtotal)	(1)	(6)	(12)	(21)	(30)	(100)	(0)	(170)	(1)	(6)	(12)	(21)	(30)	(110)	(0)	(180)	(1)	(6)	(12)	(21)	(30)	(120)	(0)	(190)
Marketing	Inland Marketing	1	1	0	2	1	2	0	7	1	1	0	2	1	2	0	7	1	1	0	2	1	2	0	7
	Export		1	0	2	1	1	0	5		1	0	2	1	1	0	5		1	0	2	1	1	0	5
	(Subtotal)	(1)	(2)	(0)	(4)	(2)	(3)	(0)	(12)	(1)	(2)	(0)	(4)	(2)	(3)	(0)	(12)	(1)	(2)	(0)	(4)	(2)	(3)	(0)	(12)
Security & Safety	Security	1	1	1	2	5	32	0	42	1	1	1	2	5	32	0	42	1	1	1	2	5	32	0	42
	Safety		1	1	2	0	1	0	5		1	1	2	0	1	0	5		1	1	2	0	1	0	5
	Fire Fighting		1	1	3	5	25	0	35		1	1	3	5	25	0	35		1	1	3	5	25	0	35
	(Subtotal)	(1)	(3)	(3)	(7)	(10)	(58)	(0)	(82)	(1)	(3)	(3)	(7)	(10)	(58)	(0)	(82)	(1)	(3)	(3)	(7)	(10)	(58)	(0)	(82)
Production Control	Production Control	1	1	2	3	3	4	0	14	1	1	2	3	3	5	0	15	1	1	2	3	3	6	0	16
	Planning		1	0	2	0	1	0	4		1	0	2	0	1	0	4		1	0	2	0	1	0	4
	Quality Control		1	1	2	7	12	0	23		1	1	2	7	16	0	27		1	1	2	7	20	0	31
	(Subtotal)	(1)	(3)	(3)	(7)	(10)	(17)	(0)	(41)	(1)	(3)	(3)	(7)	(10)	(22)	(0)	(46)	(1)	(3)	(3)	(7)	(10)	(27)	(0)	(51)
	Coal Transportation	1	1	1	2	8	48	4	65	1	1	1	2	8	48	0	61	1	1	1	2	8	48	0	61
Operation	Gasification		1	2	2	9	69	9	92		1	3	3	14	98	5	124		1	4	4	19	133	5	166
	Methanol		1	1	4	4	24	13	47		1	2	4	8	48	5	68		1	3	4	12	72	5	97
	Air Separation		1	1	3	4	16	8	33		1	1	3	4	20	4	33		1	1	3	4	24	4	37
	Power Generation		1	2	5	8	32	13	61		1	2	5	16	64	5	93		1	2	5	24	96	5	133
	Common Facilities		1	3	7	12	20	12	55		1	3	7	12	28	4	55		1	3	7	12	28	4	55
	(Subtotal)	(1)	(6)	(10)	(23)	(45)	(209)	(59)	(353)	(1)	(6)	(12)	(24)	(62)	(306)	(25)	(434)	(1)	(6)	(14)	(25)	(79)	(401)	(23)	(549)
Maintenance	Mechanical	1	1	2	8	11	20	9	52	1	1	2	8	12	23	5	52	1	1	2	8	13	26	5	56
	Instrument/Electrical		1	2	9	10	14	12	48		1	2	9	12	18	8	50		1	2	9	14	20	8	54
	(Subtotal)	(1)	(2)	(4)	(17)	(21)	(34)	(21)	(100)	(1)	(2)	(4)	(17)	(24)	(41)	(13)	(102)		(2)	(4)	(17)	(27)	(46)	(13)	(110)
Pipeline & Terminal	Pipeline	1	1	0	1	0	8	0	11	1	1	0	1	0	8	0	11	1	1	0	1	0	8	0	11
	Terminal		1	1	1	4	8	0	15		1	1	1	4	8	0	15		1	1	1	4	8	0	15
	Maintenance		1	1	1	1	4	0	8		1	1	1	1	4	0	8		1	1	1	1	4	0	8
	(Subtotal)	(1)	(3)	(2)	(3)	(5)	(20)	(0)	(34)	(1)	(3)	(2)	(3)	(5)	(20)	(0)	(34)	(1)	(3)	(2)	(3)	(5)	(20)	(0)	(34)
Total		7	27	36	86	131	445	80	812	7	27	38	87	151	564	36	910	7	27	40	88	171	679	36	1,048

G: General Manager, M: Manager, A: Assitant Manager, E: Engineer, Staff, F: Foreman O: Operator, Technician, S: Expatriate Supervisor

11. PLANT FACILITIES

11-1 ON-SITE FACILITIES

11-1-1 Gasification Plant

Coal gasification plant consists mainly of the following six processes: coal dewatering, pulverizing and injection, gasification, gas cooling, dedusting and holding. There are six gasifiers, four operating and two stand-by. Refer to Fig. 11-1-1.

(1) Process Description

1) Dewatering Process

Lump coal, the grain size of which is below 40mm, is primarily crushed to an upper grain size of about 2 mm, to allow dewatering of the coal with high efficiency.

Lump coal of 23.1% moisture is dewatered in the dewatering process as a part of the coal drying process required to maintain the heat balance in the gasifier. From the view-point of mass treatment, a steam tube dryer is employed and 23.1% moisture in coal is reduced to 15%. The heating medium in the steam tube dryer is 3.5 kg/cm^2G saturated steam.

2) Coal Pulverization and Injection Process

Coal pulverization with simultaneous drying is required to gasify the coal at a high efficiency, to maintain the heat balance in the gasifier and also to transport the coal easily.

In a vertical roller mill, the primarily dewatered coal is pulverized from a grain size of 3 mm to more than 70% of 74 micro meters and simultaneously dried from a moisture content of 15% to 10% by burning the off gas from methanol plant.

Pulverized coal in the flue gas is removed in a bag house and then conveyed to the coal injection process by pneumatic transportation.

To obtain a high carbon conversion ratio, pulverized coal should be injected onto the molten iron surface at high velocity. Pulverized coal can be constantly fed to the gasifier with help of a rotary feeder by CO_2 carrier gas. The injection process comprises two feed tanks in one train which are alternately used, so called "Multi-Feed Tank System".

3) Gasification Process

In this process, the pulverized coal and oxygen are injected onto the molten iron bath through specially developed main-lances cooled with water.

The pulverized coal is cracked instantaneously and the carbon reacts with oxygen to make generated gas mainly composed of H_2 and CO.

Ash in the coal reacts with the calcined lime which is supplied batch-wise through sub-material equipment on the gasifier and becomes a molten slag. The slag is discharged intermittently to a slag pan.

The amount of molten iron gradually decreases during operation, because some is accompanied with the generated gas as a dust and some is mixed with the discharged slag. Therefore scrap iron is also intermittently supplied through sub-material equipment.

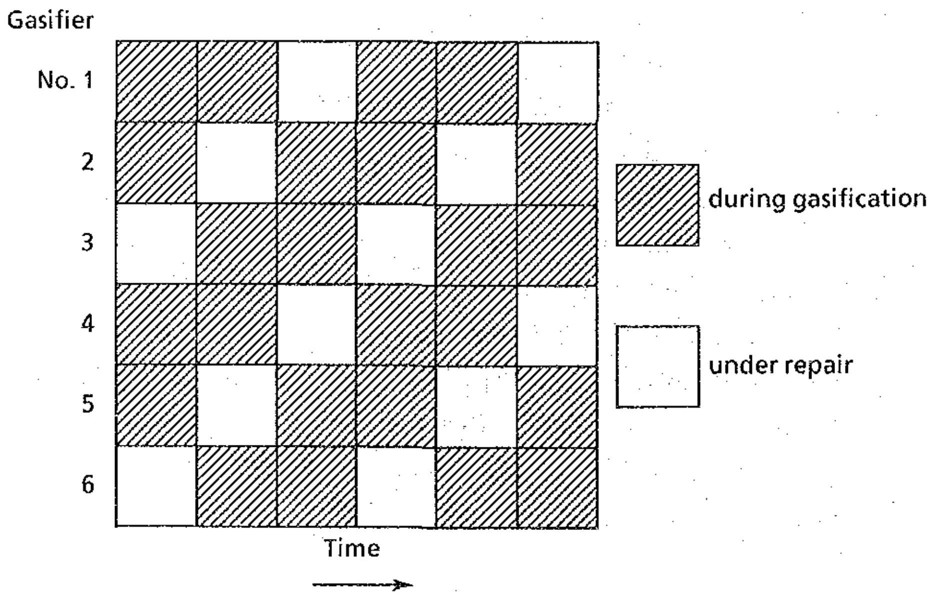
FeAl is used as a heat source to control the temperature of molten iron bath, if necessary.

A sub-lance is employed for sampling molten iron and slag to measure the temprature and composition.

To produce initial molten iron, scrap iron is melted with scrap melting burner in the pre-heated gasifier using the off-gas as a fuel.

Normally, when shutting down one gasifier due to the life of the refractory used in it, the molten iron in the gasifier is discharged to a ladle and poured from the ladle in another gasifier which is ready to operate.

In this Project, four gasifiers are always operated and two are repaired to make it possible to generate gas continuously as shown in the following figure;



4) Gas Cooling Process

The crude gas from the gasifier at 1600°C is passed through a gas cooling process to recover the sensible heat and to generate steam.
The gas is cooled down to 610°C by exchanging heat with the cooling water (BFW) having a pressure of 80 kg/cm^2G.
From the gas cooling process, saturated steam with a temperature of 300°C is recovered.

5) Dedusting Process

The gas after the gas cooling process has still a temperature of 610°C and a dust of 22.7 g/Nm^3, therefore it is cooled and dedusted by the dedusting process which is composed of a saturator and a ring-slit-washer. Industrial water is used in the process.
The gas is cooled down to about 70°C and dedusted to the content of 30 mg/Nm^3.
On the other hand, the dust is discharged outside as a slurry after thickening in a thickener.

6) Gas Holder

The gas after cooled and dedusted is compressed from 2.5 kg/cm^2G to 39 kg/cm^2G in the methanol plant.
From the view-point of stable supply of the gas, a gas holder is installed having an inner volume of 1,905 m^3 in the gasification plant.
In case of fluctuations in the gasification process the gas stored in the gas holder is available.

(2) Major Equipment

1) Mechanical Equipment

i) Description of main equipment

a) Coal pre-dewatering system

Type : Steam tube dryer

Construction : This equipment has many steam tubes with fin in a rotating cylinder.
In the cylinder, coals are agitated and heated during they are advanced.

Feature : Safety not using fire.
High heat efficiency.

b) Coal pulverizing system

Type : Vertical roller type mill

Construction : This mill is a vertical roller type one with an air separator and conveyor.
This has a rotating grinding table and a hydraulic roller which starts operation when material is fed in.

Feature : Less space for its vertical design.
Easy adjustment for fine grinding.
Drying, separating and conveying can be done simultaneously.

c) Coal ijection system

Type : Multi-feed tank system

Construction : This system is a parallel-feed type comprising two lines operated alternately.
While one line is used for injection, the other one is used for receiving pulverized coal.
Pulverized coal is carried by inert gas, in this case, by CO_2.

Feature : Safety for using inert gas.
Continuous operating can be done.
Coal feed range is wide.

d) Coal gasifier

Type : Horizontal type gasifier

Construction : This gasifier is a cylindrical steel made pressure vessel and refractory materials are pasted in it as lining.
After molten iron is poured in it, pulverized coal is blowed into the surface of molten iron with O_2 gas, then coal is converted into CO & H_2 gas (Refer to Fig. 11-1-2).

Feature : Even low grade coal can be gasified.

e) Waste heat boiler & dedusting system

Type : Waste heat boiler & dedusting system

Construction : This system is composed of two parts.
One is waste heat boiler and the other is dedusting equipment.
The former has a membrane tube in which water flows and works to cool down the high temperature gas.
It makes steam simultaneously by using this heat.
Latter is wet-type dedusting equipment.
In this equipment, water is sprayed into gas. Dust is removed from gas and dropped with water.

Feature : Steam making.
High dedusting efficiency.
Low pressure loss by using ring slit element.

ii) Equipment specification list (Refer to Table 11-1-1 and ATTACHMENT 11-1)

iii) Layout of whole coal gasification plant (Refer to Fig. 11-1-3)

iv) Layout in gasifier building (Refer to Fig. 11-1-4 of ATTACHMENT 11-1)

v) Cross section view in gasifier building (Refer to Fig. 11-1-5 and Fig. 11-1-6 of ATTACHMENT 11-1)

2) Electrical and Instrumentation Equipment

i) General Description

a) Power distribution system

Each power distribution panel is designed to make its current volume below 2,000 A (at 3.3 kV).
Maximum capacity of transformers for 440 V is 2,000 kVA.

b) Motor

The following motors are adopted; wound-rotor type motors, judging from starting current value.

- High voltage motors above 400 kW for mechanical drive
- High voltage motors above 1,000 kW for blower

Variable-speed motors are VVVF type considering maintenance ability.

c) Control system

PLC (programable logic controller) system is introduced for electrical sequence control.
Microprocessor-based distributed process control system is adoped and good man-machine interface is provided by CRT operator stations.

d) Electric room and control pulpit

Two electric rooms are installed. One covers coal preparation and injection system. The other covers coal gasifier and the down stream systems.
The control pulpit is installed in the main building and covers the operation of the whole plant.

ii) Layout of electrical room (Refer to Fig. 11-1-7 of ATTACHMENT 11-1)

iii) Single line diagram (Refer to Fig. 11-1-8 of ATTACHMENT 11-1)

iv) Piping & Instrumentation diagram (PID) (Refer to Fig. 11-1-9 of ATTACHMENT 11-1)

3) Building (Including equipment foundation)

i) Design condition and material specification

a) Design criteria

Standard specifications and codes of practice acceptable for use in design are those of Japan.

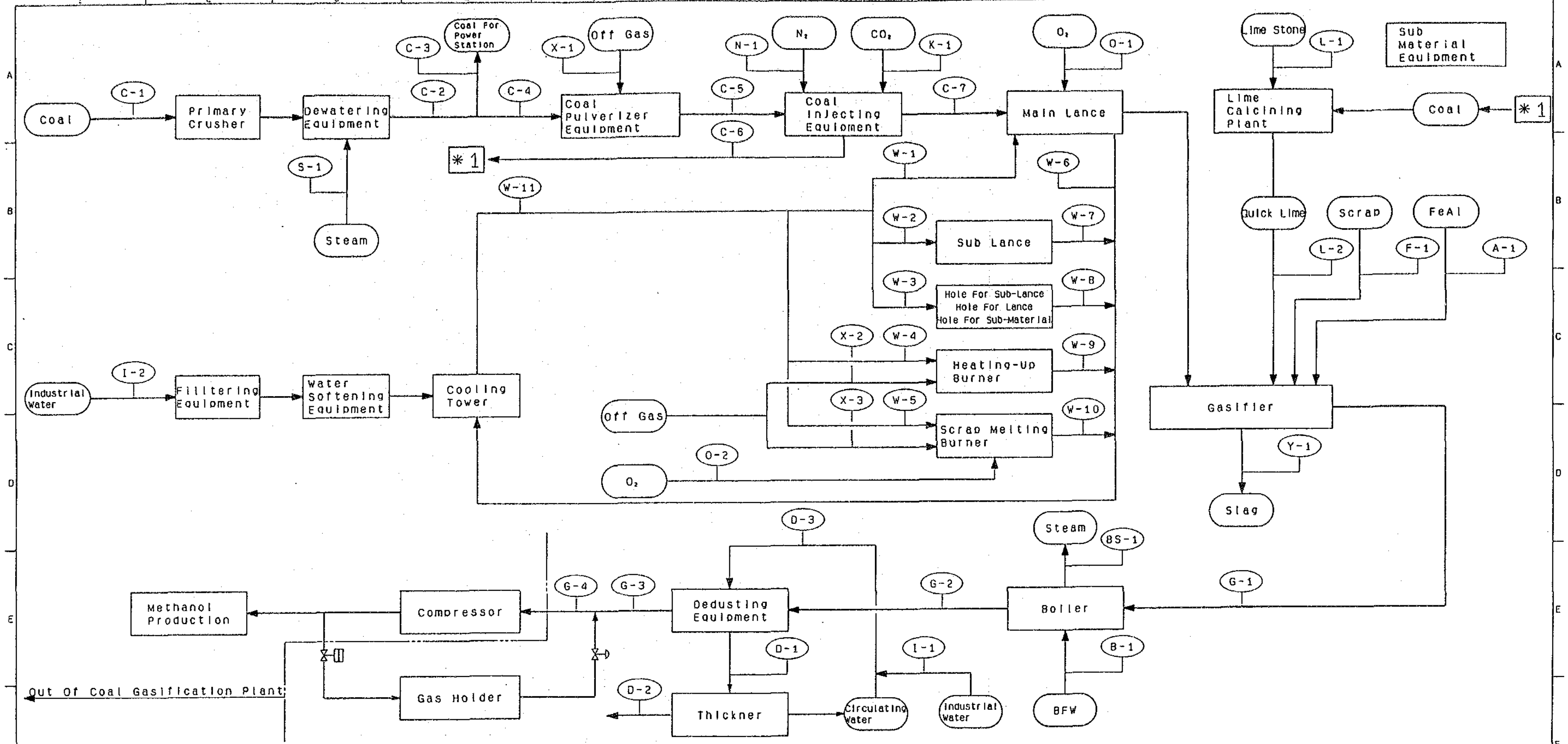
b) Material specification

Foundation : Reinforced concrete
Compressive strength of concrete is 210 kg/cm^2 (28 days)

Process building

- Type of structure : steel
- Structural steel materials conform to JIS :
  SS41 (JIS G 3101), SM50 (JIS G 3106)
- Exterior finishing
  Siding : Corrugated, metal t=0.5mm
  Roof : Ditto
- Painting of steel
  Prime coat : red lead iron oxide
  Finishing coat : synthetic resin emulsion paint
- Ventilation : monitor

ii) General view of building (Refer to Fig. 11-1-10 of ATTACHMENT 11-1)



Fluid		Coal							CGS Gas				Steam	Off Gas		
Tag. No		C-1	C-2	C-3	C-4	C-5	C-6	C-7	G-1	G-2	G-3	G-4	S-1	X-1	X-2	X-3
Phase	—	Solid	Solid	Solid	Solid	Solid	Solid	Solid	Solid&Gas	Solid&Gas	Gas	Gas	Gas	Gas	Gas	Gas
Temp.	°C	32	50	50	50	80	35	35	1600	610	50~80	32	156	32	32	32
Pressure	kg/cm²G	0	0	0	0	0	0	15	3.0	2.8	2.5	2.5	3.5	2	2	2
Flow	Nm³/hr	—	—	—	—	—	—	—	474244	474244	459917 ~513743	448695	—	6783	28404	44437
	ton/hr	435.29	393.81	125.7	268.11	253.21	1.21	252	—	—	—	—	57.7	—	—	—
Moisture	%	23.1	15	15	15	10	10	10	6.5	6.5	3.6~13.7	1.2	—	—	—	—
Dust	g/Nm³	—	—	—	—	—	—	—	22.7	22.7	0.03	0.03	—	—	—	—
Slurries	%	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Fluid		CO_2	N_2	O_2		Quick Lime		Scrap	FeAl	Slag	BFW		Industrial Water		Dust Slurries		
Tag. No		K-1	N-1	O-1	O-2	L-1	L-2	F-1	A-1	Y-1	B-1	BS-1	I-1	I-2	D-1	D-2	D-3
Phase	—	Gas	Gas	Gas	Gas	Solid	Solid	Solid	Solid	Liquid	Liquid	Gas	Liquid	Liquid	Solid &Liquid	Solid &Liquid	Liquid
Temp.	°C	32	32	32	32	32	32	32	32	1600	125	290	32	32	60	55	55
Pressure	kg/cm²G	15.0	6	10.0	10.0	0	0	0	0	0	1.5	75	6.0	6.0	0	0	8
Flow	Nm³/hr	12600	12600	121819	9666	—	—	—	—	—	—	—	—	—	—	—	—
	ton/hr	—	—	—	—	7.8	4.3	3.41	20t/charge	10.52	330	320	86.1	73.0	1967	53.0	2000
Moisture	%	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust	g/Nm³	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Slurries	%	—	—	—	—	—	—	—	—	—	—	—	—	—	0.55	20	50ppm

Fluid		Cooling Water										
Tag. No		W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8	W-9	W-10	W-11
Phase	—	Solid &Liquid	Solid &Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid	Liquid
Temp.	°C	32	32	32	32	32	60	60	60	60	60	32
Pressure	kg/cm²G	12	12	12	12	12	1	1	1	1	1	12
Flow	Nm³/hr	—	—	—	—	—	—	—	—	—	—	—
	ton/hr	800	140	100	160	180	800	140	100	160	180	1380
Moisture	%	—	—	—	—	—	—	—	—	—	—	—
Dust	g/Nm³	—	—	—	—	—	—	—	—	—	—	—
Slurries	%	—	—	—	—	—	—	—	—	—	—	—

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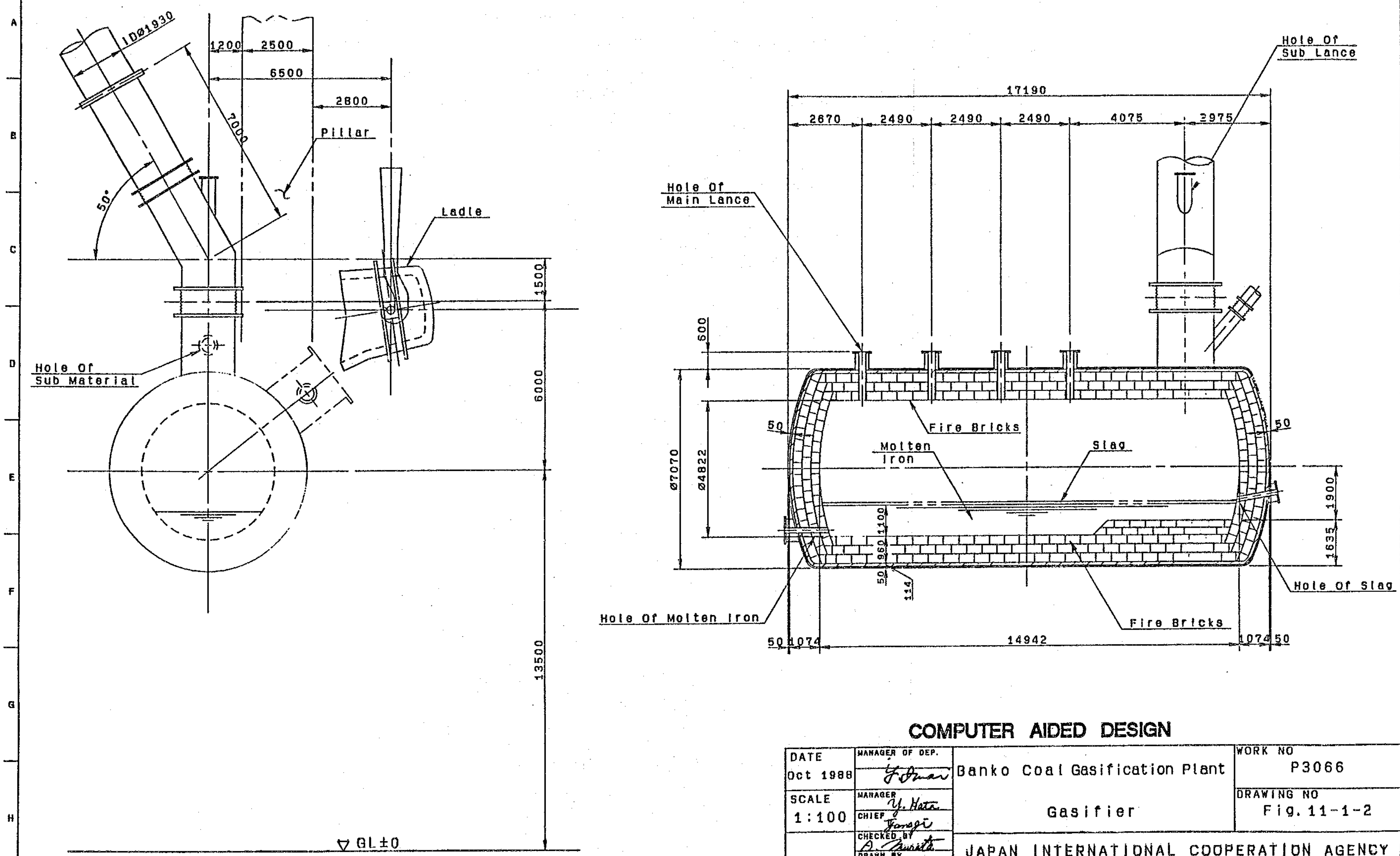
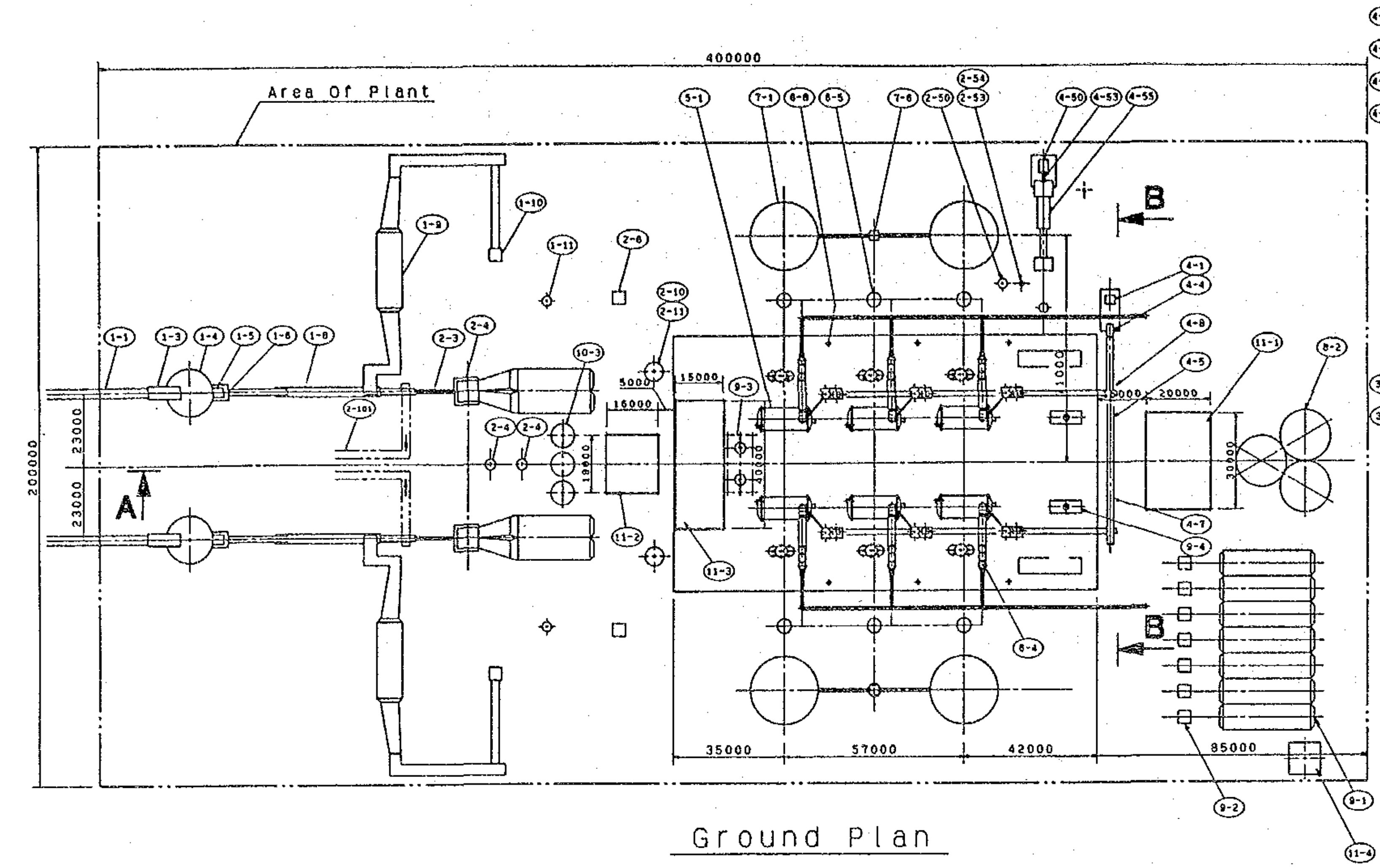
DATE Oct. 1988	MANAGER OF DEP.	Banko Coal Gasification Plant	WORK NO P3066
SCALE	MANAGER / CHIEF	Process Flow Diagram	DRAWING NO Fig. 11-1-1
	CHECKED BY / DRAWN BY	JAPAN INTERNATIONAL COOPERATION AGENCY	

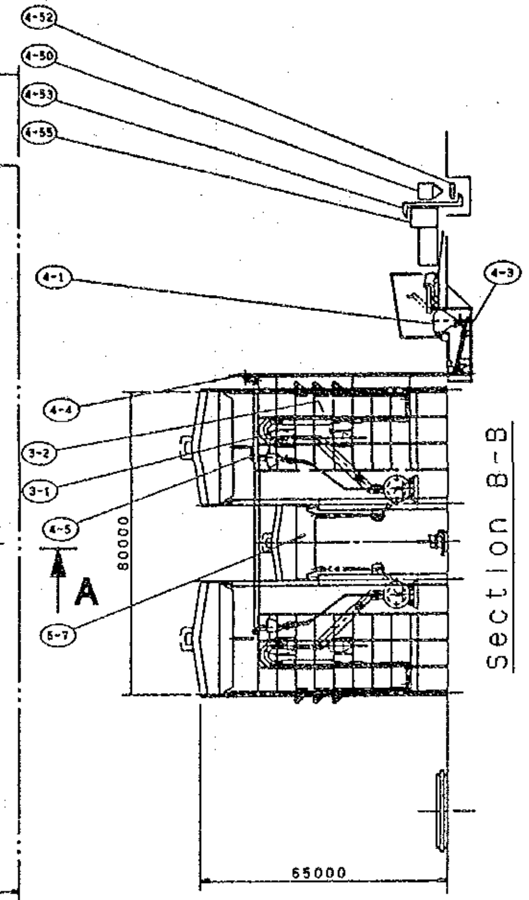


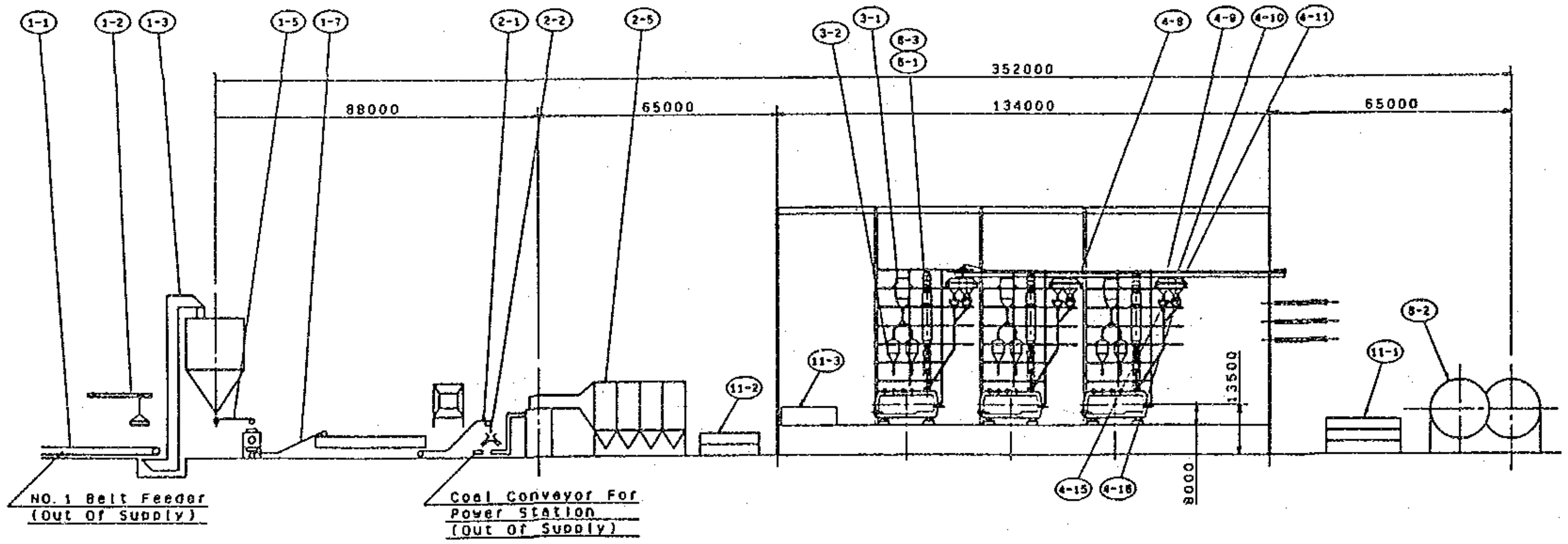
COMPUTER AIDED DESIGN

DATE Oct 1988	MANAGER OF DEP.	Banko Coal Gasification Plant	WORK NO P3066
SCALE 1:100	MANAGER Y. Hata / CHIEF / CHECKED BY / DRAWN BY	Gasifier	DRAWING NO Fig. 11-1-2
		JAPAN INTERNATIONAL COOPERATION AGENCY	



Ground Plan





Section A-A

Title	Itm No.	Service	No Reqd	Remark's
Electric Room etc	- 4	Resistance Room	1	
	- 3	Instrumentation & Operation's Room	1	
	- 2	Material Electric Room	1	
	11- 1	Main Electric Room	1	
Water Softening Equipment	- 5	Cooling Water Circulating Pump (2)	3	
	- 4	Cooling Water Circulating Pump (1)	3	
	- 3	Cooling Tower	3	
	- 2	Water Softener	1	
	10- 1	Industrial Water Filter	1	
Auxiliary Equipment	- 5	Fork Lift	2	
	- 4	Brick Conveying Equipment	2	
	-3-2	Blower For Preheating Burner	2	
	-3-1	Preheating Equipment	2	
	- 3	Ladle Preheating Equipment	2	
	- 2	Dust Collector Blower	2	
	9 - 1	Environmental Dust Collector	2	
Gas Holder Equipment	- 4	Holder Outlet Valve (2)	2	
	- 3	Holder Outlet Valve (1)	1	
	- 2	Gas Holder	3	
	8 - 1	Holder Inlet Valve	6	
Water Treatment Equipment	- 6	Collective Water Tank	2	
	- 5	Dust Collector Water Pump	8	
	- 4	Thickener Pump	8	
	- 3	Chemical Feed Pump	2	
	- 2	Chemical Feed Tank	2	
	7 - 1	Thickener	4	

Title	Itm No.	Service	No Reqd	Remark's
GasCooling & Dedusting Equipment	- 9	Gas Stop Valve	12	
	- 8	Flare Stack	6	
	- 7	Three Way Valve	6	
	- 6	Waste Water Pump	12	
	- 5	Waste Water Tank	6	
	- 4	Wet Type Dust Collector	6	
	- 3	Boiler Circulating Pump	24	
	- 2	Waste Heat Boiler Drum	6	
	6 - 1	Waste Heat Boiler	6	
Coal Gasification Equipment	-16	Drill Machine Tapping Hole	2	
	-15	Ladle Turning Table	1	
	-14	Overhead Traveling Crane For Lance	2	
	-13	Sub Lance Elevator	6	
	-12	Scrap Melting Burner	4	
	-11	Furnace Heating-Up Burner Blower	1	
	-10	Furnace Heating-Up Burner	4	
	- 9	Main Lance Elevator	24	
	- 8	Sub Lance	6	
	- 7	Ladle Crane	1	
	- 6	Slag Dump	2	
	- 5	Mud Gun	6	
	- 4	Slag hole Of Drill Machine	6	
	- 3	Slag Pot	6	
	- 2	Ladle	6	
	5 - 1	Gasifier	6	
Sub Material Equipment	-63	Quick Lime Conveyor (2)	1	
	-62	Quick Lime Discharge Feeder	1	
	-61	Quick Lime Storage Hopper	1	
	-60	Quick Lime Bucket Conveyor	1	
	-59	Quick Lime Conveyor (1)	1	
	-58	Exhaust Stack	1	
	-57	Exhaust Blower	1	
	-56	Dust Collector	1	
	-55	Lime Calciner	1	
	-54	Lime Stone Conveyor (2)	1	
	-53	Lime Stone Bucket Conveyor	1	
	-52	Lime Stone Conveyor (1)	1	
	-51	Lime Stone Discharge Feeder	1	
	-50	Lime Stone Receiving Shoot	1	
	-16	Scrap.FeAl Scale Hopper	6	
	-15	Quick Lime Scale Hopper	6	
	-14	FeAl Discharger	6	
	-13	Scrap Discharger	6	
	-12	Quick Lime Discharger	6	
	-11	FeAl Hopper	6	
	-10	Scrap Hopper	6	
	- 9	Quick Lime Hopper	6	
	- 8	Sub Material Conveyor (4)	2	
	- 7	Sub Material Conveyor (3)	2	
	- 6	Distributor	1	
	- 5	Sub Material Conveyor (2)	1	
	- 4	Sub Material Bucket Conveyor	1	
	- 3	Sub Material Conveyor (1)	1	
	- 2	Sub Material Discharge Feeder	1	
	4 - 1	Sub Material Receiving Shoot	1	
Coal Injecting Equipment	- 4	Main Lance	24	
	- 3	Pulverized Coal Discharge Feeder	12	
	- 2	Pulverized Coal Injection Tank	12	
	3 - 1	No.2 Pulverized Coal Surge Hopper	6*	
Coal Pulverizer & Drying Equipment	-101	Coal Conveyor For Power Station	2	
	-55	Pulverized Coal Injection Tank	1	
	-54	Pulverized Coal Surge Hopper	1	
	-53	Pulverized Coal Conveyor	1	
	-52	Exhaust Fan	1	
	-51	Pulverized Coal Collector	1	
	-50	Pulverized Coal Discharge Feeder	1	
	-11	Pulverized Coal Feed Tank	2	
	-10	No.1 Pulverized Coal Surge Hopper	2	
	- 9	Bucket Elevator	2	
	- 8	Belt Conveyor	2	
	- 7	Exhaust Stack	2	
	- 6	Exhaust Fan	2	
	- 5	Pulverized Coal Collector	2	
	- 4	Coal Pulverizer	2	
	- 3	Coal Feeder	2	
	- 2	Distributor	2	
	2 - 1	Coal Feeder	2	
Coal Dewatering Equipment	-11	Exhaust Stack	2	
	-10	Dust Collector Exhaust Fan	2	
	- 9	Dust Collector	2	
	- 8	Dewatering Drum	2	
	- 7	No.2 Belt Feeder	2	
	- 6	Primary Crusher	2	
	- 5	Coal Feeder	2	
	- 4	Coal Hopper	2	
	- 3	Bucket Elevator	2	
	- 2	Magnetic Separator	2	
	1 - 1	No.1 Belt Feeder	2	

DATE Oct. 1988	MANAGER OF DEP.	Banko Coal Gasification Plant Lay Out Of Whole Coal Gasification Plant	WORK NO P3066
SCALE 1:1000	MANAGER / CHIEF / CHECKED BY / DRAWN BY		DRAWING NO Fig. 11-1-3
		JAPAN INTERNATIONAL COOPERATION AGENCY	

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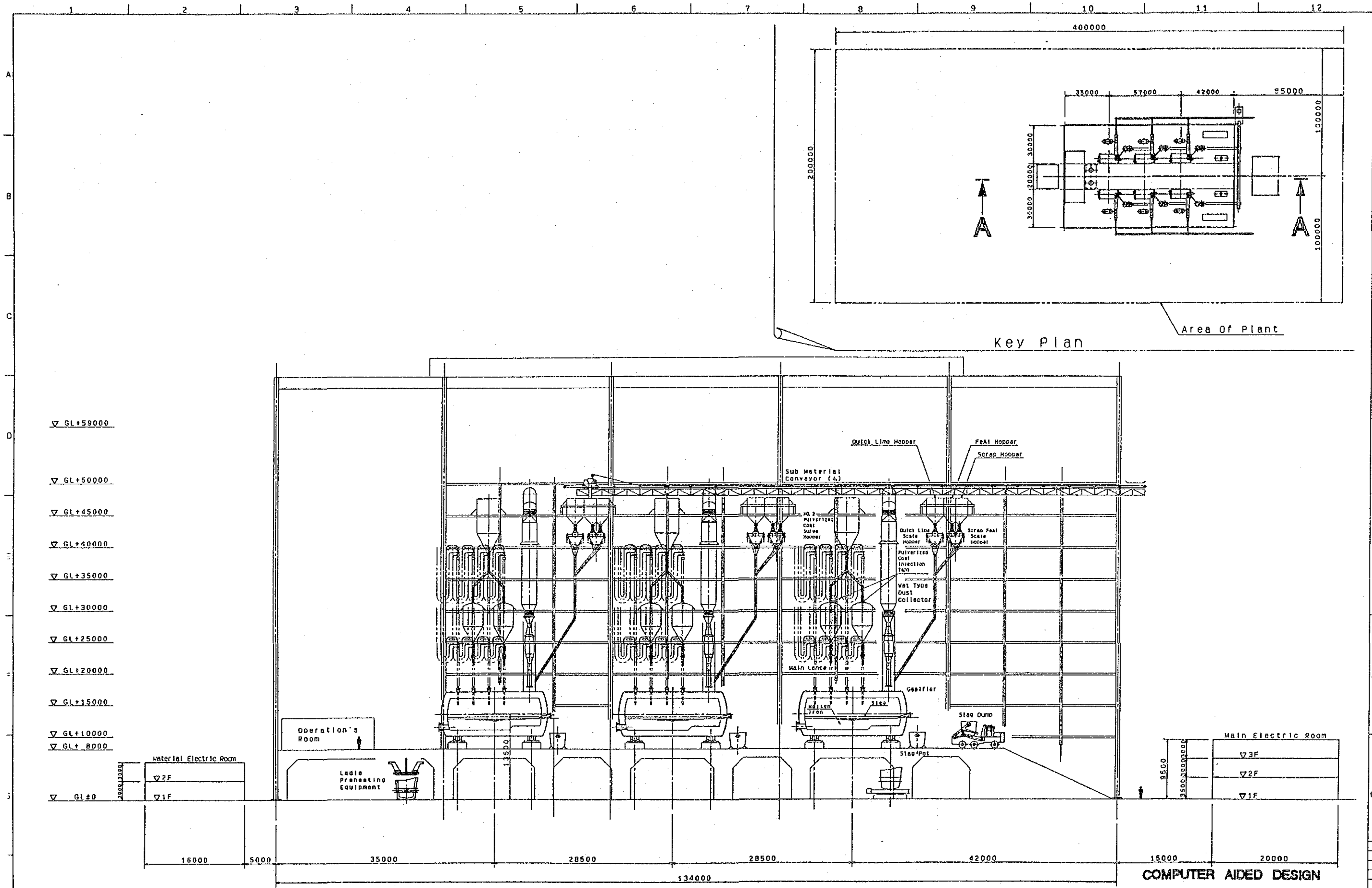

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SECTION A-A

DATE Oct. 1988	MANAGER OF DEP.	Banko Coal Gasification Plant Cross Section View Of Gasifier Building (Section A-A)	WORK NO P3066	
SCALE 1:300	MANAGER CHIEF		DRAWING NO Fig. 11-1-5	
	CHECKED BY DRAWN BY	JAPAN INTERNATIONAL COOPERATION AGENCY		

Table 11-1-1 Major Equipment
(Gasification Plant)

Description	Q'ty	Specification	
Dewatering Drum	2	*Type*	: *Steam Tube Dryer*
		Capa.	: 240 t/h
		Mo. in coal	: 23.1% / 15%
		Motor	: 490 kW
		Weight	: 4,200 t
Coal Pulverizer	2	Type	: Vertical Roller Mill
		Capa.	: 150 t/h
		Coal grain sige	: 74 μm×70% up
		Motor	: 1,600 kW
		Weight	: 450 t
Pulverized Coal Discharge Feeder	12	Type	: Rotary Feeder
		Capa.	: 70 t/h
		Motor	: 15 kW
Main Lance	24	Type	: Fourfold Tube Water Cooled Lance
		Dimension	: 250φ×9,500 L
		Material	: Copper & Carbon Steel
Gasifier	6	Type	: Horizontal type
		Dimension	: 7,100φ×17,190 L
		Iron bath weight	: 277 t
		Material	: Carbon Steel
		Weight	: 1,546 t
Ladle Crane	1	Type	: Overhead Travelling Crane
		Capa.	: 250 t (Main Hook)
		Weight	: 300 t
Sub Lance	6	Type	: Threefold Tube
		Dimension	: *100φ × 13,500 L*
		Material	: Carbon Steel
Waste Heat Boiler	6	Type	: Water Cooling Membrane Wall
		Gas flow rate	: 118,560 Nm^3/N
		Gas temperature	: 1,600°C / 610°C
		Weight	: 150 t
Wet Type Dust Collector	6	Type	: Saturater & Ring Slit Washar
		Gas temperature	: 610°C / 70°C
		Weight	: 50 t

(For details, see *ATTACHMENT 11-1*)

11-1-2 Methanol Plant

The crude synthesis gas produced in the coal gasification plant is purified and converted to chemical grade methanol in this plant.
The methanol plant consists of three trains of 1,500 t/d production.
Total production rate is:

$$3 \times 1{,}500 = 4{,}500 \text{ t/d}$$

The number of trains is decided through consideration of its economics and the market study, as described in Chapter 9.

(1) Process Description

Refer to the attached Process Flow Diagrams Fig. 11-1-11 (1/2) and (2/2), and Table 11-1-2.

The methanol process plant consists of

- Raw Gas Booster Section (# 100)
- CO Shift Section (# 200)
- Acid Gas Removal Section (# 310)
- Compression Section (# 300)
- Methanol Synthesis Section (# 400)
- Methanol Distillation Section (# 500)
- The relevant steam system

1) Raw Gas Booster Section

The raw gas, which is sent from the gasification plant through dedusting of the gas, shall be compressed up to 39.0 kg/cm^{2}G by a centrifugal compressor of two casings K101 BOOSTER which shall be driven by a steam trubine. The discharge pressure of K101 Booster shall be controlled by the speed of the steam turbine.
The interstage of each section in the compressor shall be cooled by cooling water in the heat exchangers.

2) CO Shift Section

The boosted-up raw gas shall be introduced into two reactors of CO shift catalyst in series, R201 No.1 Shift Converter and R202 No.2 Shift Converter after mixing with the required quantity of the middle pressure steam for CO shift reaction. The catalyst is a sulfur tolerant catalyst to make the reactions:

$CO + H_2O \rightarrow CO_2 + H_2$

$COS + H_2O \rightarrow CO_2 + H_2S$

From the chemical stoichiometry for the methanol synthesis, CO shall be converted to hydrogen to produce the synthesis gas of the composition after the acid gas removal,

$[H_2] / (2[CO] + 3[CO_2])$ = approximately 1.0

Approximately 30% of the raw gas shall be by-passed around the CO shift reactors in order to maintain the concentration of CO gas in the synthesis gas.

The hot converted gas from R201 No.1 Shift Converter shall be heat-exchanged with the feed raw gas, and the boiler feed water in E201 Shift Waste Heat Boiler where a part of the required process steam for shift reaction is generated. The remaining part of the steam is supplied from R401 Methanol Converter in the Synthesis section.

The hot gas from R202 No. 2 Shift Converter shall be heat-exchanged with the feed gas to R301 Hydrogenator in E302 HDS Preheater.

The converted gas from CO Shift Converters is mixed with the other by-passed raw gas, and sent to T310 Absorber in the Acid Gas Removal Section after heat recovery in series of heat exchangers, i.e.

- E203 LP Waste Heat Boiler where the low pressure steam is generated.
- E310 Regenerator Reboiler where the heat is supplied for steam stripping of the regenerator.
- E509 LP Refining Column Reboiler where the reboiling heat is supplied for T503 LP Refining Column,
- E502 Topping Column Reboiler where the reboiling heat is supplied for T501 Topping Column.

The low pressure steam from E203 is utilized as supplementary heat for T502 HP Refining Column in E507 HP Refining Column Steam Reboiler.

3) Acid Gas Removal Section

The converted gas from CO Shift Section shall be introduced into T310 Absorber where CO_2, H_2S and COS shall be absorbed by hot potassium carbonate solution in three steps, i.e. bulk section, semi-rich section and lean section.

$K_2CO_3 + H_2S \rightarrow KHCO_3 + KHS$

$K_2CO_3 + CO_2 + H_2O \rightarrow 2KHCO_3$

$COS + H_2O \rightarrow H_2S + CO_2$

COS is converted to H_2S and CO_2 in activated hot potassium carbonate solution but the reaction rate is not so high as CO_2 conversion.

Consequently the hydrogenation and the sulfur adsorption shall be provided as sulfur guard after Acid Gas Removal Section.

The rich solution leaving the bottom of Absorber is sent to T312 Semi Regenerator where the bulk of acid gas is stripped from the solution and the relatively low regenerated solution is produced at the bottom that is recycled to the rich section at the bottom of T310 Absorber.

The semi-rich solution leaving from the middle of Absorber is sent to T311 Regenerator where the acid gas is finally stripped with regenerating the solution into two streams, i.e. semi-lean solution and lean solution that are sent to each section of Absorber respectively.

Both of the above two streams from Absorber have an enough static head that can be recovered as power through hydraulic turbines, HT310 Rich Hydroturbine and HT311 Semi Rich Hydroturbine. These hydraulic turbines supplement the required power for the pumps, P312 Lean Solution Pump and P310 Bulk Solution Pump.

Most of regeneration heat is supplied by the waste (latent) heat of the converted gas in E310 Regenerator Reboiler. The regeneration heat for T312 Semi Regenerator, is supplied by the sensible heat of the semi lean solution from T311 Regenerator.

And the stripping steam for the bulk section at the top of T312 Semi-Regenerator is supplied from the top of T311 Regenerator as well as the recovered steam from the bottom of T312 that is compressed by K310 Vapor Compressor.

The acid gas from T312 Semi Regenerator is cooled in E311 Acid Gas Condenser and to be vented at the stack.

Thus the system has an energy efficient heat recovery.

4) Compression Section and Sulfur Guard

After Acid Gas Removal Section, the composition of the synthesis gas is adjusted to the stoichiometric ratio of H_2 to $CO + CO_2$ favorable for the synthesis. But the synthesis gas has a small content of sulfur components leaked through Acid Gas Absorber, which shall be treated in R301 Hydrogenator where the sulfur compounds are converted to H_2S, and in R302 Sulfur Adsorber where H_2S is adsorbed by ZnO, i.e.

$$COS + H_2 \rightarrow CO + H_2S$$
$$ZnO + H_2S \rightarrow ZnS + H_2$$

The sulfur shall be removed from the synthesis gas, thus down to less than 0.1 ppm.

The catalyst of R301 Hydrogenator will be Ni-Mo or Co-Mo, that of R302 Adsorber is ZnO.

The heat for preheating the syuthesis gas is supplied by the waste heat of the effluent from R202 No.2 Shift Converter.

After the final removal of sulfur the synthesis gas is compressed up to 88 kg/cm^2G by a centrifugal compressor of a single case, K301 Syn Gas Compressor that shall be driven by a steam turbine, K301T Syn Gas Turbine. The suction pressure of the compressor shall be controlled by the speed of the steam turbine.

5) Synthesis Section

The synthesis gas that is compressed by K301 is mixed up with the recycled syn gas from V401 Methanol Separator, and to be fed to R401 Methanol Converter after preheated by the effluent gas in E401 Feed Preheater.

The converter is a double-tube heat exchanger where the catalyst is loaded in the annular space of the double tube and it is cooled by boiler water flowing outside of the tube as well as the feed gas flowing inside the inner tube. Major part of reaction heat is utilized to generate the middle pressure (more than 40 kg/cm^2G) steam as much as 1.0 t/t of produced methanol. This generated steam shall be used for the process steam for CO shift reaction.

The hot effluent gas is sent to three heat recovery exchangers, i.e. E401 Feed Preheater, E402 BFW Preheater to heat BFW for R401 Convertor and E403 Purge Gas Preheater to heat the purge gas.

After heat recovery the effluent gas shall be cooled to condense the produced methanol together with water.

The condensed methanol that contains water and the byproducts, i.e. the crude methanol is separated in V401 Methanol Separator and the remained unreacted gas is recycled to K302 Circulator that is driven by a steam turbine. Thus the loop of synthesis section is completed.
A part of the recycled gas shall be purged out of the loop in order to avoid the excessive accumulation of inert gas such as CH_4, Ar, etc. The purge gas drives a turbo expander to generate electric power after preheated.

The separated crude methanol is once flashed in V402 Let Down Tank where the dissolved gas is vented. The crude methanol is fed to the Distillation Section through TK802 Crude Methanol Pump.

6) Distillation Section

The crude methanol is fed to T501 Topping Column after preheated by the hot condensate from the converted gas streams in E501 Crude Methanol Heater.
The dissolved gas such as CO_2 is stripped off in T501 from which the crude methanol is sent to T502 HP Refining Column.
The reboiling heat for T502 is supplied by the waste heat of the converted gas in the CO Shift section.
A refining column is split into two columns, the higher pressure column T502 and the lower pressure column T503 in order that the latent heat of overhead vapor at the higher pressure column is utilized for the reboiling heat for the lower pressure column.
The total required heat could be saved by a half of that for a single column with this heat integration, and the cooling water is also saved so much.
The reboiling heat for T502 is supplied by LP steam in E507 HP Refining Column Steam Reboiler. A part of product methanol is yielded at the top of T502. The remained methanol, which contains still the water and the heavier impurities, is sent to T503 LP Refining Column where the other part of product methanol is yielded at the overhead, the concentrated heavier impurities are drawn out as side-cut at the middle of the column, and the water is distilled at the bottom to be sent outside of battery limit as waste water.

(2) Major Equipment (3 trains)

See Table 11-1-3.

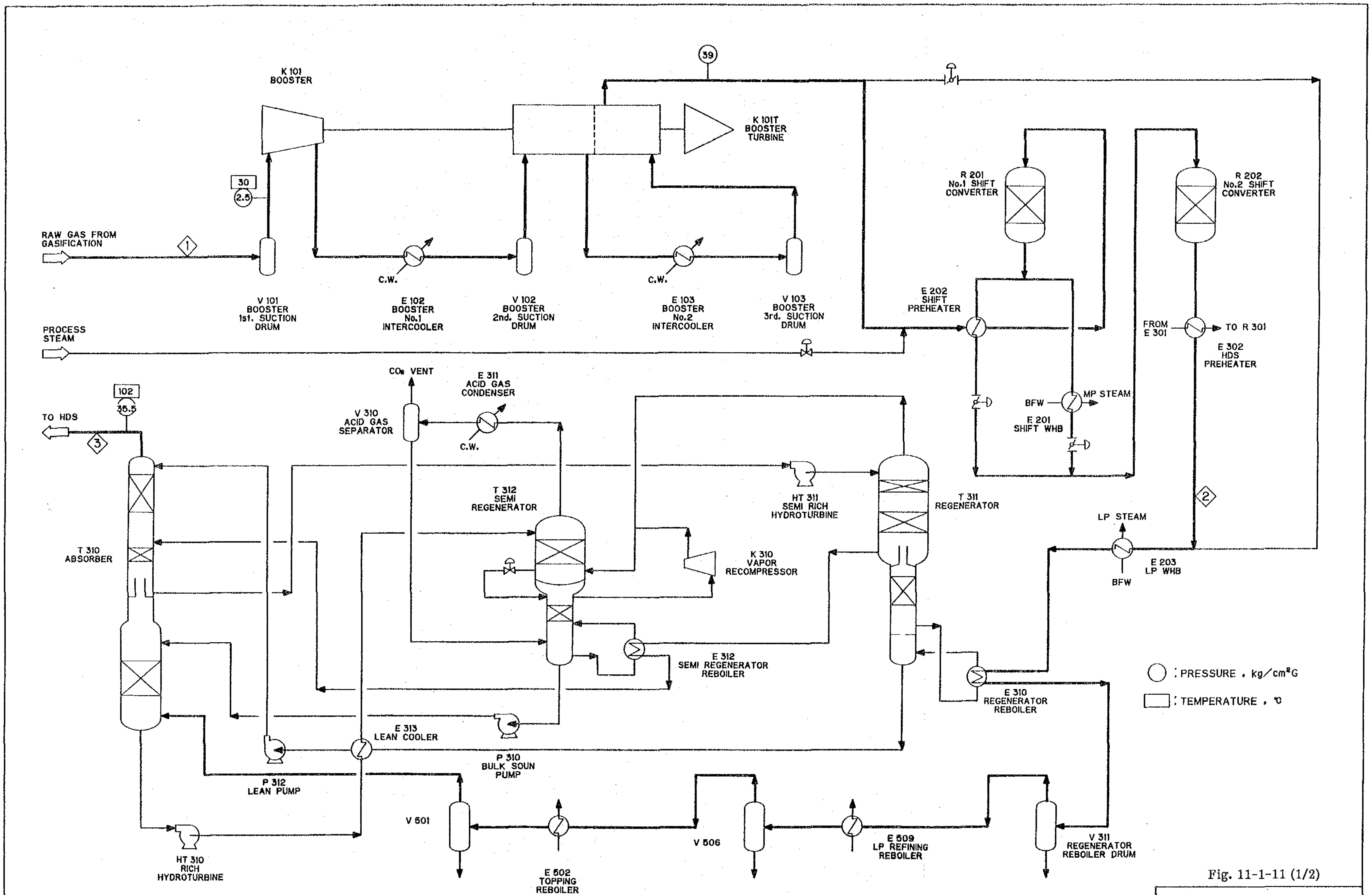


Fig. 11-1-11 (1/2)

METHANOL PLANT
PROCESS FLOW DIAGRAM
(1/2)

JAPAN INTERNATIONAL COOPERATION AGENCY

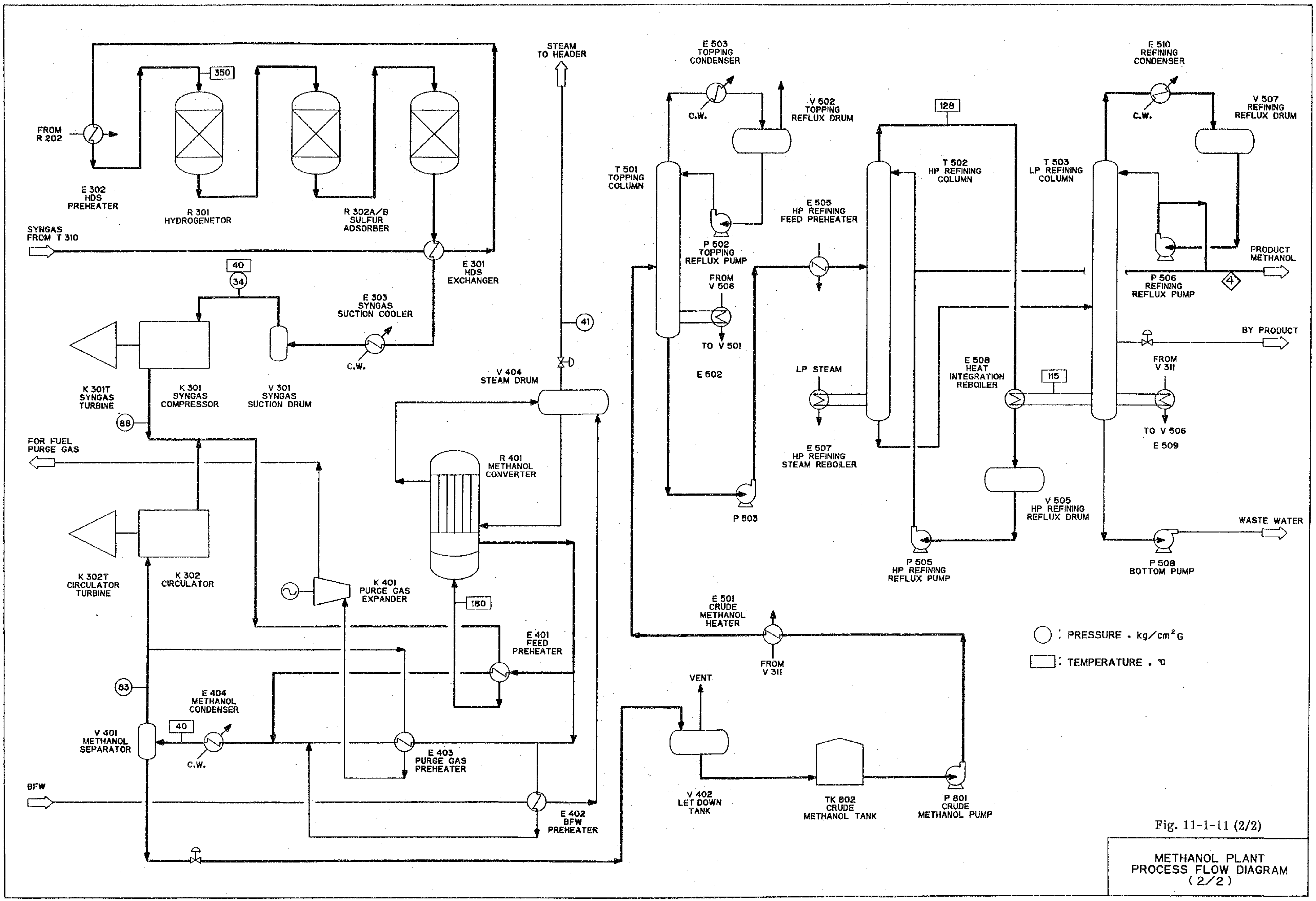


Fig. 11-1-11 (2/2)

METHANOL PLANT
PROCESS FLOW DIAGRAM
(2/2)

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 11-1-2 Stream Data for Methanol Plant per Train

STREAM NO.		◇1	◇2	◇3
FLOW RATE	(Nm^3/h)	158,200	210,000	152,000
COMPOSITON				
CO_2	(DRY MOL. %)	3.64	37.82	5.00
CO	(DRY MOL. %)	65.83	7.00	26.53
H_2	(DRY MOL. %)	30.08	54.88	68.05
N_2	(DRY MOL. %)	0.43	0.28	0.42
H_2S + COS	(DRY MOL. %)	0.02	0.02	20 ppm

STREAM NO.		◇4
FLOW RATE	(t/h)	62.5
COMPOSITON		
CH_3OH	(Wt%)	$\geqq$ 99.9
H_2O	(Wt%)	$\leqq$ 0.1

Note: ◇1 ~ ◇4 ; Refer to Fig. 11-1-11.

Table 11-1-3 Major Equipment (3 trains) (Methanol Plant)

Name	No.	Specification
K101 Booster	3 × 1	Ps = 2.5kg/cm^2G Pd = 39 kg/cm^2G Flow = 158,200 Nm^3/h Power = 18,000 kW
R201/R202 No.1 & No.2 Shift Converter	3 × 2	Cylindrical Vessels Flow = 106,000 Nm^3/h Exit CO = 7 mol.%
T310	3 × 1	Packed Column S. S. Pall Ring Exit CO_2 = 5 mole % 55 m height 5.0 m ID
T311	3 × 1	Packed Column S. S. Pall Ring 50 m Height 4.0 m ID
K301	3 × 1	Centrifugal Type Ps = 34 kg/cm^2G Pd = 88 kg/cm^2G 6,800 kW
K302 Circulator	3 × 1	Centrifugal Type 1,300 kW
R401 Converter	3 × 1	Tubular Reactor Temp. Inlet = 180°C Exit MeOH = 12.4 mole % Steam Generation: 80 t/h
T501 Topping Column	3 × 1	Trayed Column Height 35 m 3.0 m ID
T502 HP Refining Column	3 × 1	Trayed Column Height 58 m 3.5 m ID
T503 LP Refining Column	3 × 1	Trayed Column 54 m Height 5.0 m ID

11-1-3 Air Separation Plant

Supplyng oxygen to the Coal Gasification Plant as well as nitrogen to each plant is the function of the Air Separation Plant which consists of air separator, oxygen compressor and nitrogen compressor.

(1) Process Description

Fig. 11-1-12 and Fig. 11-1-13 show the overall block flow diagram of Air Separation Plant and the simplified process flow diagram of Air Separator.

1) Pretreatment

Feed air to be separated is taken from the top of an air filter where solid contamination is removed.
Clean air which is free from solid contamination is compressed to required pressure (about 5.4 kg/cm^{2}G) by a feed air compressor driven by a steam turbine and sent to a trickling cooler and cooled down to about 5°C by direct contact with cooling water and chilled water.
Feed air is then sent to molecular sieves air dryers (adsorbers).
In molecular sieves air dryers, the remaining water and carbon dioxide are removed to permit the feed air to go into the cryogenic cold box system.
The waste nitrogen from the upper part of an upper rectifying column is used for the reactivation stream of molecular sieves.

2) Cooling Down

Most of the air from a molecular sieve air dryer is introduced to the cold box and cooled to cryogenic temperature in an air heat exchanger against pure oxygen, pure nitrogen and waste nitrogen.
Some of the air from a molecular sieve air dryer is compressed by an air blower connected to an expansion turbine and cooled down by an aftercooler and a turbine air precooler.
The boosted air is introduced to a cold box and cooled down in an air heat exchanger.
It is withdrawn from the middle part of an air heat exchanger, then expanded through an expansion turbine to provide refrigeration duty and fed to an upper rectifying column.

3) Air Separation into Oxygen and Nitrogen

Initial separation of the air into an oxygen-rich liquid fraction (liquid air) and a gaseous nitrogen fraction is accomplished in a lower rectifying column while final separation into pure oxygen and pure nitrogen is effected in an upper rectifying column.

After passing through a liquid air supercooler, liquid air is expanded and introduced as the feed into an upper rectifying column.

Liquid nitrogen is extracted from the middle part of a lower rectifying column, expanded and fed to an upper rectifying column as reflux.

In an upper rectifying column, the liquid air and reflux nitrogen are separated into product pure oxygen, pure nitrogen and waste nitrogen.

Product pure oxygen is withdrawn from the bottom of an upper rectifying column, warmed in an air heat exchanger to ambient temperature and sent to an oxygen compressor.

Product pure nitrogen is withdrawn from the top of an upper rectifying column, warmed in a liquid nitrogen supercooler and an air heat exchanger to ambient temperature and sent to a nitrogen compressor.

The waste nitorgen is withdrawn from the upper part of an upper rectifying column and warmed in a liquid air supercooler and an air heat exchanger before going out from the cold box.

Most of waste nitrogen is introduced to an evaporating cooler where the water from a trickling cooler is cooled against the waste nitrogen and discharged to the atmosphere.

The rest of the waste nitrogen is introduced to a reactivation preheater and a reacitivation heater and used to reactivate the molecular sieves in molecular sieves air dryers.

4) Product Compression

Product pure oxygen (99.5 vol%) is compressed to 15 kg/cm^{2}G by an oxygen compressor driven by a steam turbine and sent to the gasification plant.

Product pure nitrogen (98.0 vol%) is compressed to 7 kg/cm^{2}G by a nitrogen compressor and sent to each plant.

(2) Major Equipment

Specification and the number of units of major equipment are listed in Table 11-1-4.

Fig. 11-1-14 shows a plot plan of major equipment.

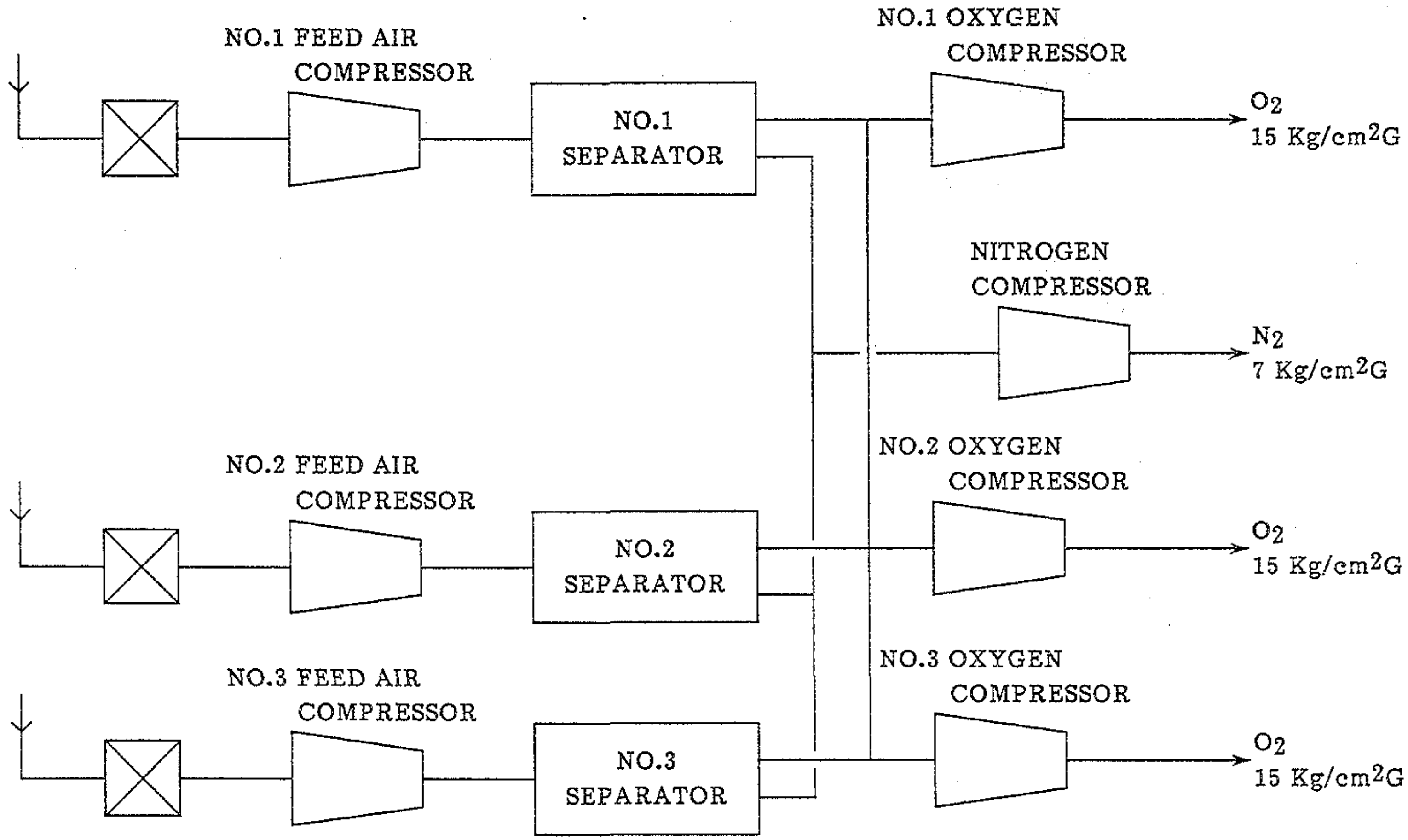
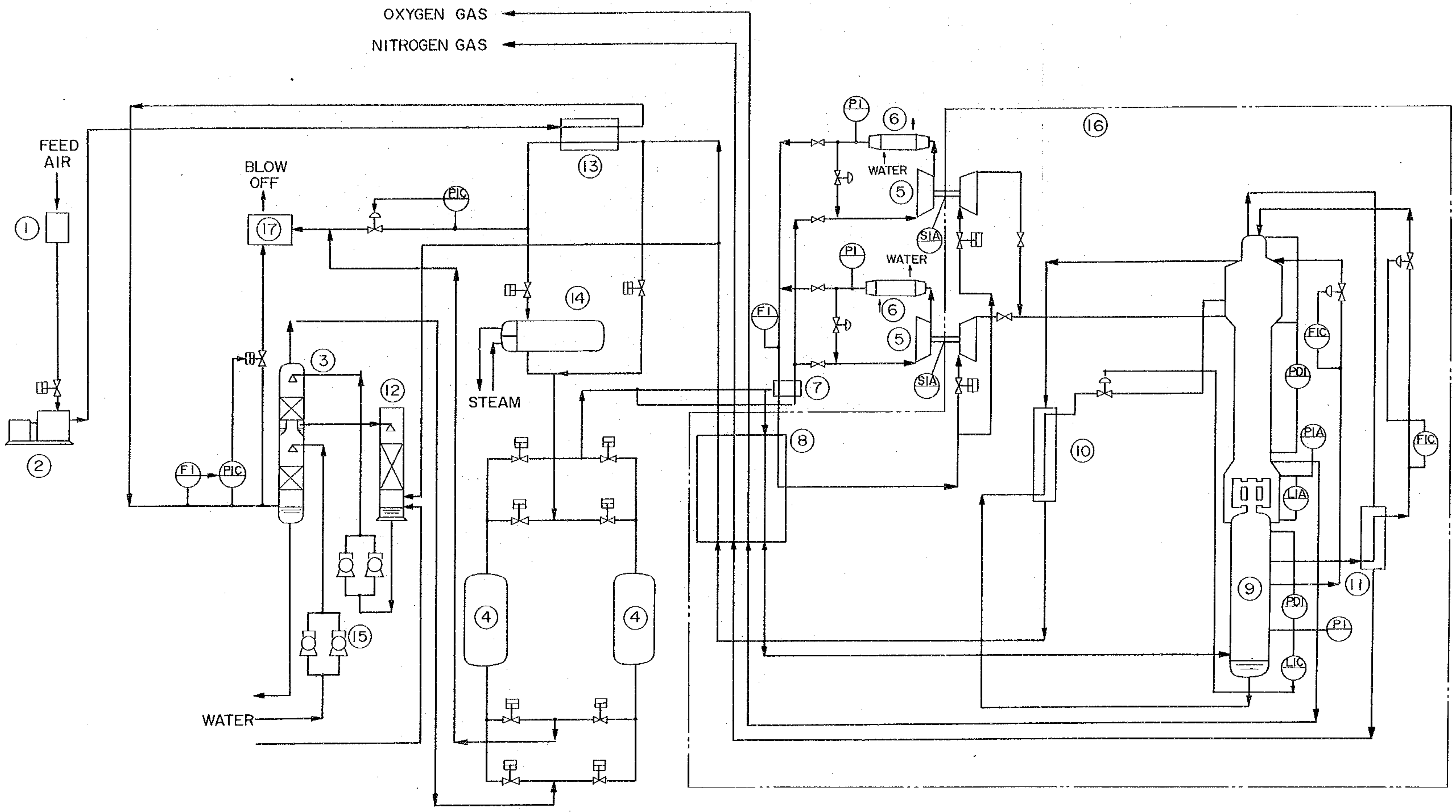


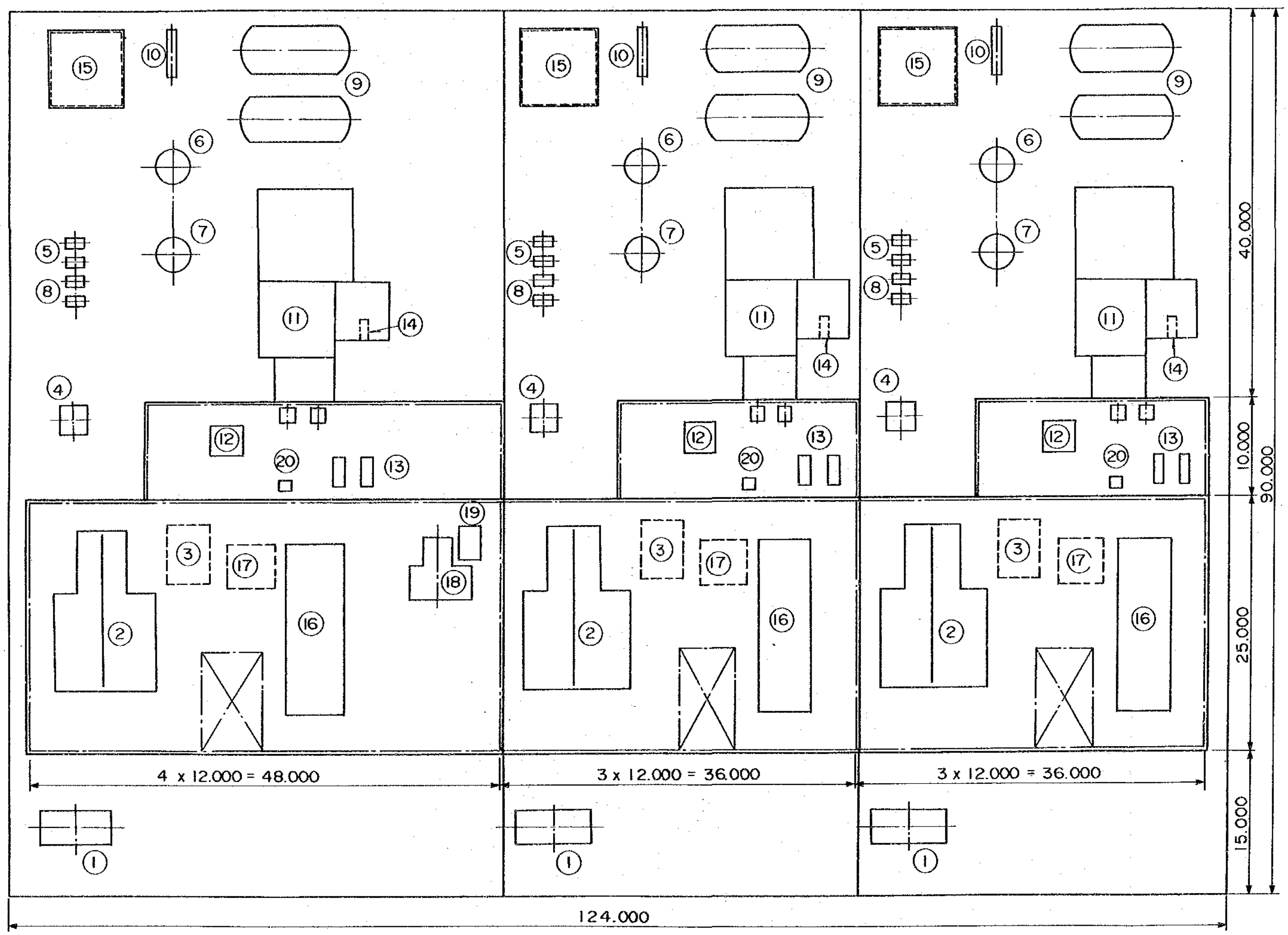
Fig. 11-1-12 Block Flow Diagram of Air Separation Plant



No.	MAIN UNITS	No.	MAIN UNITS	No.	MAIN UNITS
1	AIR FILTER	8	AIR HEAT EXCHANGER	15	WATER PUMPS
2	AIR COMPRESSOR	9	RECTIFYING COLUMN	16	COLD BOX
3	TRICKLING COOLER	10	LIQUID AIR SUPER COOLER	17	SILENCER
4	ABSOREERS	11	LIQUID NITROGEN SUPER COOLER		
5	EXPANSION TURBINE	12	EVAPORATING COOLER		
6	AFTER-COOLER	13	REACTIVATION RPE-HEATER		
7	TURBINE AIR PRE-COOLER	14	REACTIVATION HEATER		

Fig. 11-1-13 Simplified Process Flow Diagram for Air Separatoin Plant

JAPAN INTERNATIONAL COOPERATION AGENCY



NAME OF EQUIPMENT

No.	MAIN UNIT
1	AIR FILTER
2	AIR COMPRESSOR
3	LUBE OIL UNIT OF AIR COMP
4	REACTIVATION PRE-HEATER
5	WATEP PUMPS
6	TRICKLING COOLER
7	EVAPORATING COOLER
8	WATER CIRCULATION PUMPS
9	ADSORBERS
10	REACTIVATION HEATER
11	COLD BOX
12	TURBINE AUXILIARY EQUIPMENT
13	AFTER COOLER OF TURBINE COMP
14	LIQUID OXYGEN BLOW EVAPOPLTOR
15	SILENCER
16	OXYGEN COMPRESSOR
17	LUBE OIL UINIT OF OXYGEN COMP
18	NITROGEN COMPRESSOR
19	LUBE OIL UNIT OF NITROGEN COMP
20	PRE-COOLER OF EXP. TURBINE

Fig. 11-1-14 Layout of Air Separation Plant

JAPAN INTERNATIONAL COOPERATION AGENCY

Table 11-1-4 Major Equipment
(Air Separation)

Description	Q'ty	Specification	
Trickling Cooler	3	Dimension	: 3 mφ × 18 m^H
		Material	: Carbon steel
		Weight	: 35 t
Evaporating Cooler	3	Dimension	: 2.5 mφ × 8 m^H
		Material	: Carbon steel
		Weight	: 17 t
Adsorber	6	Dimension	: 4 mφ × 12.5 m^L
		Material	: Carbon steel
		Weight	: 50 t
Upper Rectifying Column	3	Dimension	: 4.2 mφ × 19 m^H
		Material	: Aluminum-alloy
		Weight	: 18 t
Lower Rectifying Column	3	Dimension	: 4 mφ × 10 m^H
		Material	: Aluminum-alloy
		Weight	: 30 t
Feed Air Compressor	3	Dimension	: 204,000 Nm^3/h
		Discharge Pressure	: 5.4 kg/cm^2G
Ditto, Driver	3	Steam Turbine	: 16,200 kW
Oxygen Compressor	3	Capacity	: 40,700 Nm^3/h
		Suction/Discharge Pressure	: 0.2/15 kg/cm^2G
		Weight	: 35 t
Ditto, Driver	3	Steam Turbine	: 5,400 kW
Nitrogen Compressor	1	Capacity	: 26,600 Nm^3/h
		Suction/Discharge Pressure	: 0.03/7 kg/cm^2G
Ditto, Driver	1	Steam Turbine	: 2,300 kW

11-1-4 Power Plant

(1) Process Description

Process Flow Diagram: See Fig. 11-1-15.

1) The plant consists of 3 units of 37MW extraction condensing turbine generator set and 3 units of fluidized bed boiler.
Capacity of each set corresponds to each set of methanol production plant.

2) Fluidized bed boiler is especially suitable for low grade coal and high sodium content coal in ash such as Banko coal, keeping the excellent combustion efficiency and low NOx and SOx emission in the wide range of the operating load as described in Section 7-3.

3) Extraction condensing turbine is suitable for supplying necessary electric power and process steam for the Project on the condition isolated from utility grids.

4) The feed water, which is heated and removed from the dissolved oxygen by a deaerator equipped as one of the utility facilities, is boosted up by a boiler feed pump and sent to the fluidized bed boiler
Saturated steam (75 atg) from the gasification plant is superheated to HP process steam temperature (480°C) by the superheater equipped in the fluidized bed boiler and sent to the HP process pipeline (65 atg, 480°C).

5) The turbine is of 2 points extraction condensing type.
High pressure extraction steam (65 atg) is sent to HP process pipeline (65 atg, 480°C) and low pressure extraction steam (3.5 atg) is sent to LP process pipeline (3.5 atg, 156°C).
Condensate in the hotwell tank of the condenser is boosted up by a condensate pump and sent to the deaerator already described above in 4).

6) The generator is of 3-phase, 2 pole, 50 Hz, cylindrical synchronous type.
Generated electricity having the 11 kV voltage is transmitted to the electricity receiving and distribution center and to be distributed to each plant.

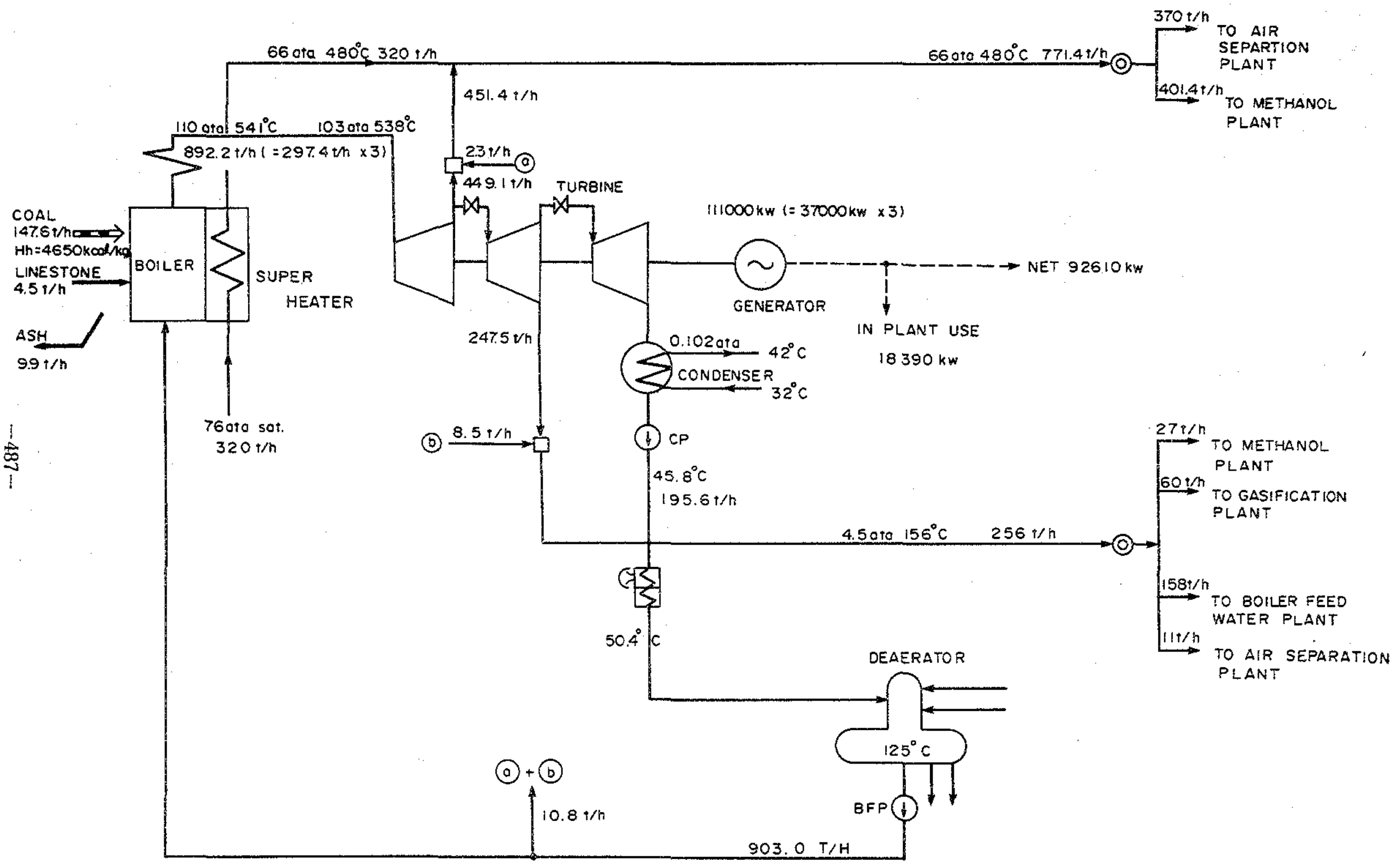


Fig. 11-1-15 Power Plant Heat Balance

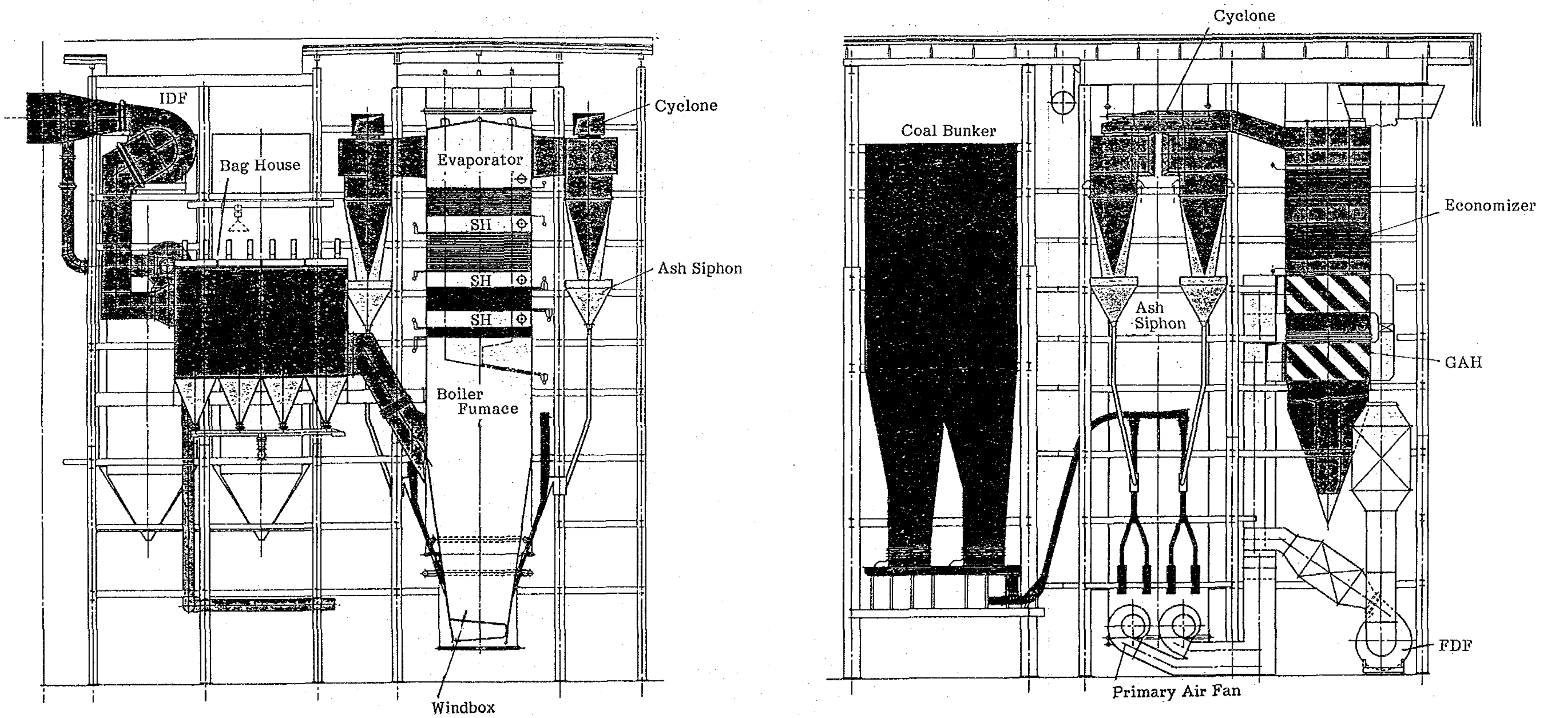


Fig. 11-1-16 Example of Sectional View of Fluidized Bed Boiler

(2) Major Equipment

Specification and the number of major equipment are listed in Table 11-1-5.

Table 11-1-5 Major Equipment
(Power Plant)

Description	Q'ty	Specification
Fluidized Bed Boiler	3	298 t/h, 109 atg, 541°C/126°C
Steam Turbine/Generator Unit	3	37,000 kW
Boiler Feed Pump	6	340 t/h, 125 atg
Steam Condenser	3	64.8 t/h, 685 mmHgV
Vacuum Pump	3	685 mmHgV
Condensate Pump	6	82 t/h, 120 mAq

(3) Electricity Distribution System

1) Balance and System

Electricity balance is shown in Fig. 11-1-17.

Generated electricity is transmitted from Electric Power Plant through power cables at 11,000 volt.

In Electricity Receiving and Distribution Center, this high tension electricity is distributed to Air Separation Plant, Cooling Water Plant and Water Treatment Plant at 11 kV via underground cable wiring system. As for Coal Gasification Plant, Methanol Plant and auxiliary facilities, electricity is distributed at 3,300 volt.

See the One Line Diagram in Fig. 11-1-18.

2) Equipment List

Major equipment is listed in Table 11-1-6.

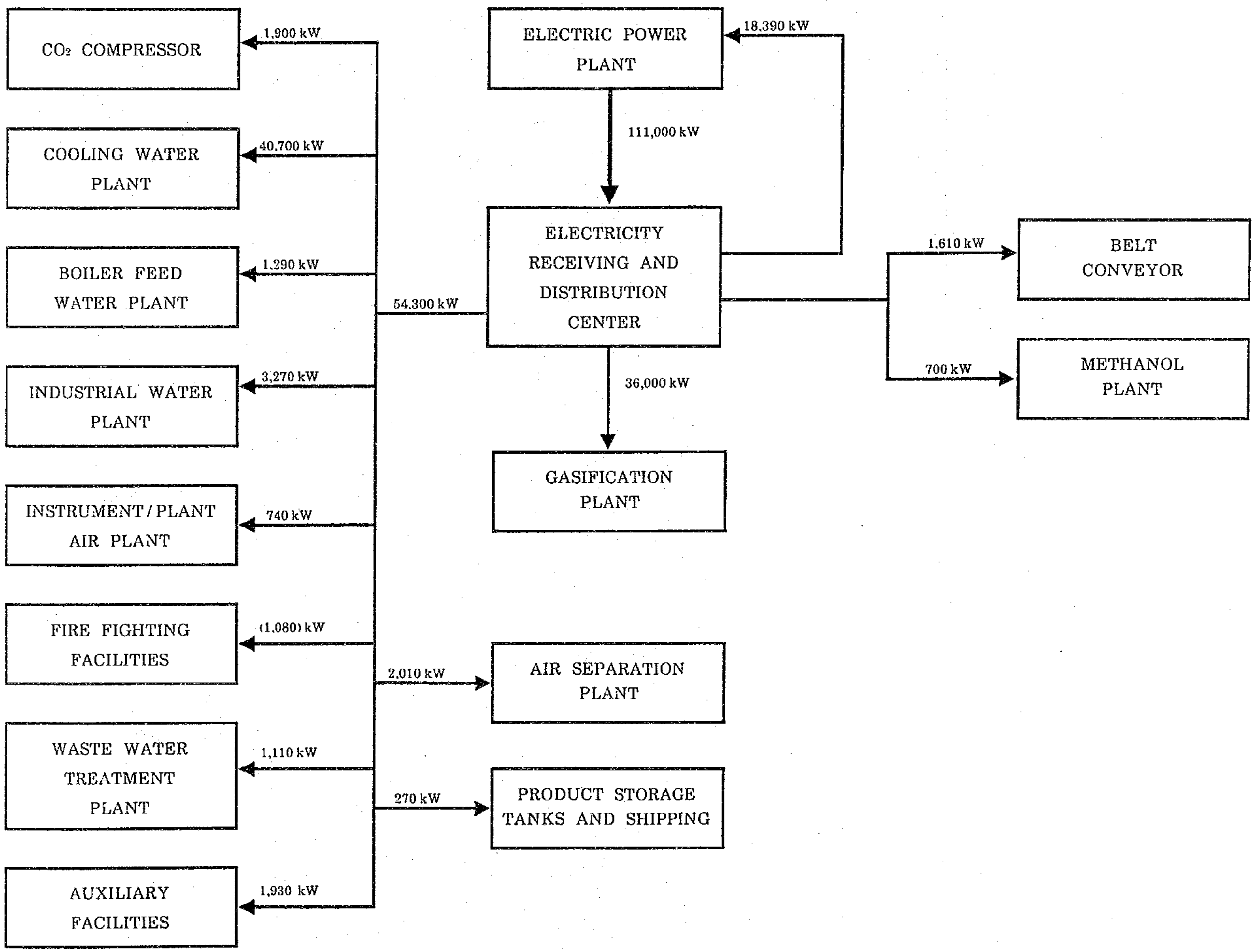


Fig. 11-1-17 Electricity Balance

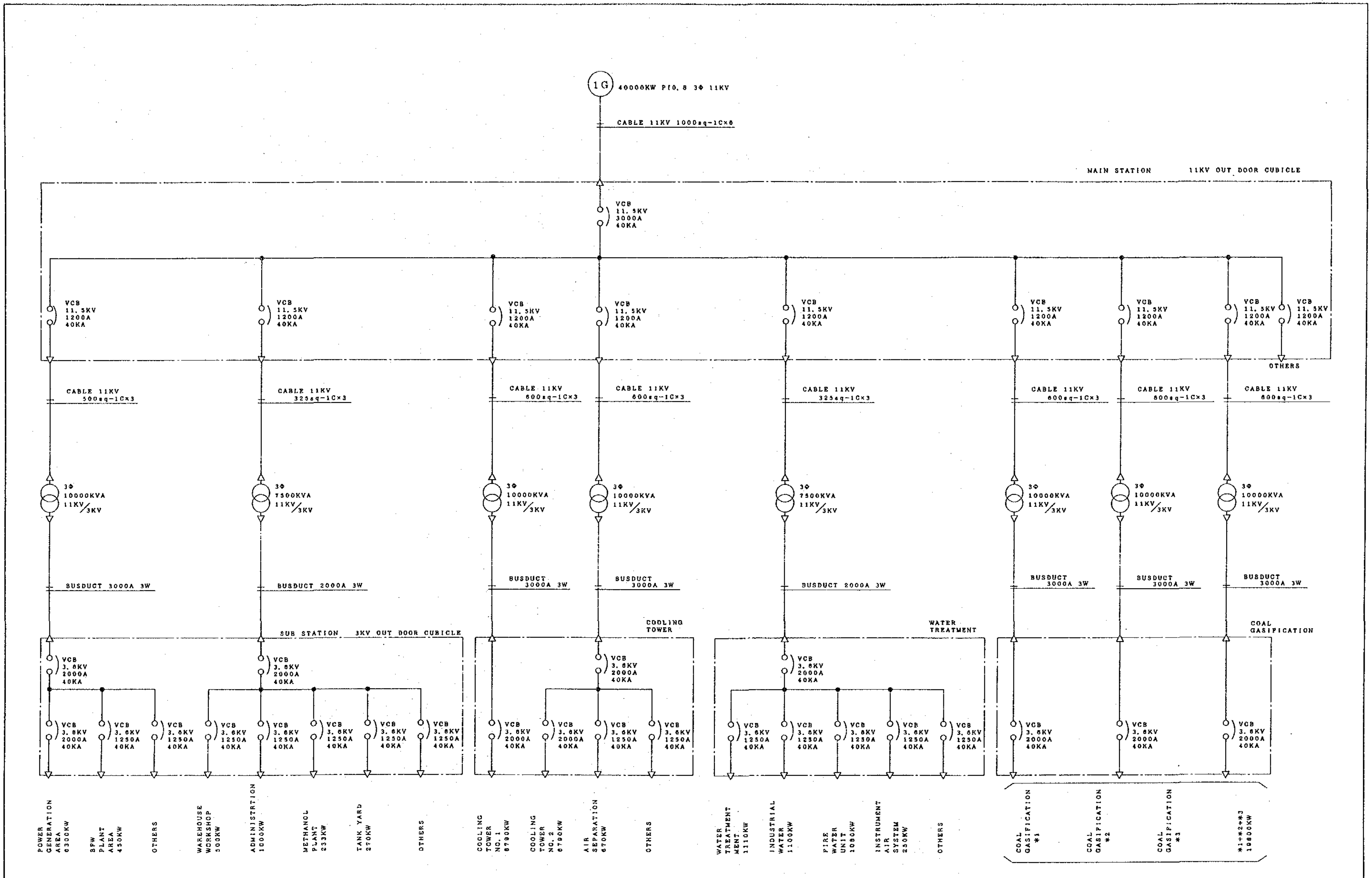


Fig. 11-1-18 ELECTRICITY DISTRIBUTION SYSTEM ONE LINE DIAGRAM

JAPAN INTERNATIONAL COOPERATION AGENCY

(THE FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL)

ELECTRICITY DISTRIBUTION SYSTEM ONE LINE DIAGRAM

Table 11-1-6 Major Equipment
(Electricity Distribution System)

Description	Q'ty	Specification
1. Electricity Distriution Area		
(1) 11 kV Switchgear Cubicle	10	11 kV, VCB Outdoor type
(2) 11 kV PT. Unit Cubicle	2	
(3) Transformer	1	11 kV/3 kV 10,000 kVA
	1	11 kV/3 kV 7,500 kVA
(4) Protection Relay Panel Board	1	Indoor type
(5) Supervisory Panel Board	1	
(6) Data Logging System	1	
(7) 3 kV Switchgear Cubicle	10	VCB, Outdoor type
(8) 3 kV PT. Unit Cubicle	2	
2. Local Plant Area		
(1) Transformer	5	11 kV/3 kV 10,000 kVA
	1	11 kV/3 kV 7,500 kVA
(2) 3 kV Switchgear Cubicle	14	VCB, Outdoor type
(3) 3 kV PT. Unit Cubicle	6	

11-1-5 Utility Facilities

Utility facilities consist of a water treatment system which includes Cooling Water Plant, Boiler Feed Water Plant and Industrial/Service Water Plant, Instrument/Service Air Plant and others.

(1) Cooling Water Plant

1) System

Cooling water system is shown in Fig. 11-1-19.

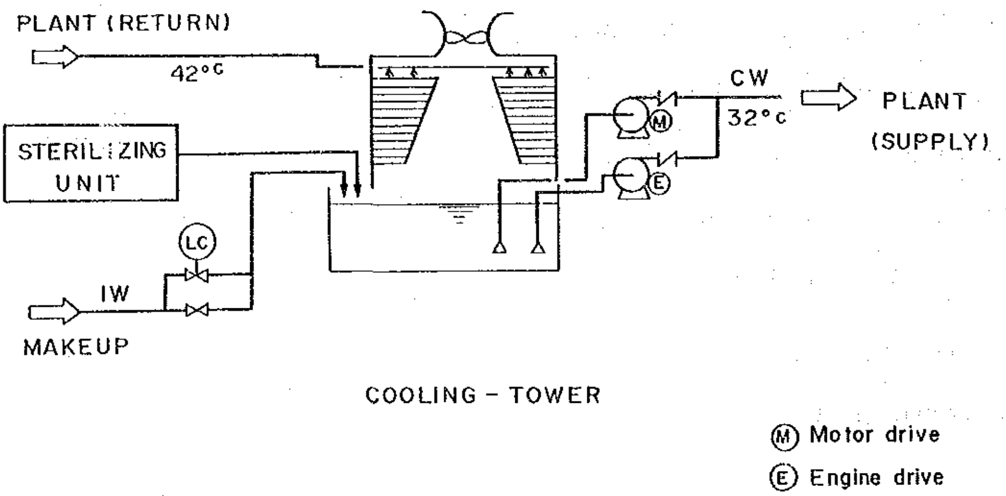


Fig. 11-1-19 Cooling Water Plant Flow

Cooling water is supplied from the Cooling Water Plant to the Methanol Plant, the Air Separation Plant and the Electric Power Plant at 32°C and returned at 42°C after cooling the process gas and liquid, steam turbine condensate and compressed gas to required temperature.
In the Cooling Water Plant, water returned is cooled down to 32°C by forced draft cooling tower.
Normally, 2% of circulating cooling water is lost in the cooling towers accompanied by air into atmosphere and 1% of circulating cooling water is blown down for controling the content of impurities in circulating water. Therefore, 3% of the cooling water is lost and to be made up from industrial water.

2) Basic Design Data

i) No. of trains : three

ii) No. of units : 22 units/train

iii) Unit capacity : 1,500 t/h unit

iv) Inhibitors to be added

	Name (Effect)	Type	Usage condition
a)	Corrosion inhibitor (anti-corrosion and scale control)	Low metallic	60 mg/l
b)	Scale deposit dispersant (inhibit the generation of scales and deposits)	High-molecular type	50 mg/l
c)	Microorganism control agent (Slime control)	Hypochlorite	20 mg/l

3) Major Equipment

Specification and the number of units of major equipment are listed in Table 11-1-7.

Fig. 11-1-20 shows a sketch of cooling tower.

Table 11-1-7 Major Equipment
(Cooling Water Plant)

Description	Q'ty	Specification
Cooling Tower Pit	66	Volume : 600 m^3 Material : Concrete
Cooling Tower	66	Type : Forced draft Temperature : 32°C/42°C Capacity : 1,500 m^3/h (20 m^W × 9 m^L × 10 m^H) Material : Concrete, Resine Driver : Motor (100 kW) Type : Centrifugal
Cooling Water Pump	66	Capacity : 1,500 m^3/h × 8 kg/m^2G Material : Carbon Steel Driver : Motor (470 kW)
Chemicals Feed Unit	12	Capacity Vessel : 2 m^3 Pump : 100 l/h × 4 kg/m^2G
Vacuum Pump Unit	12	Material : Carbon steel

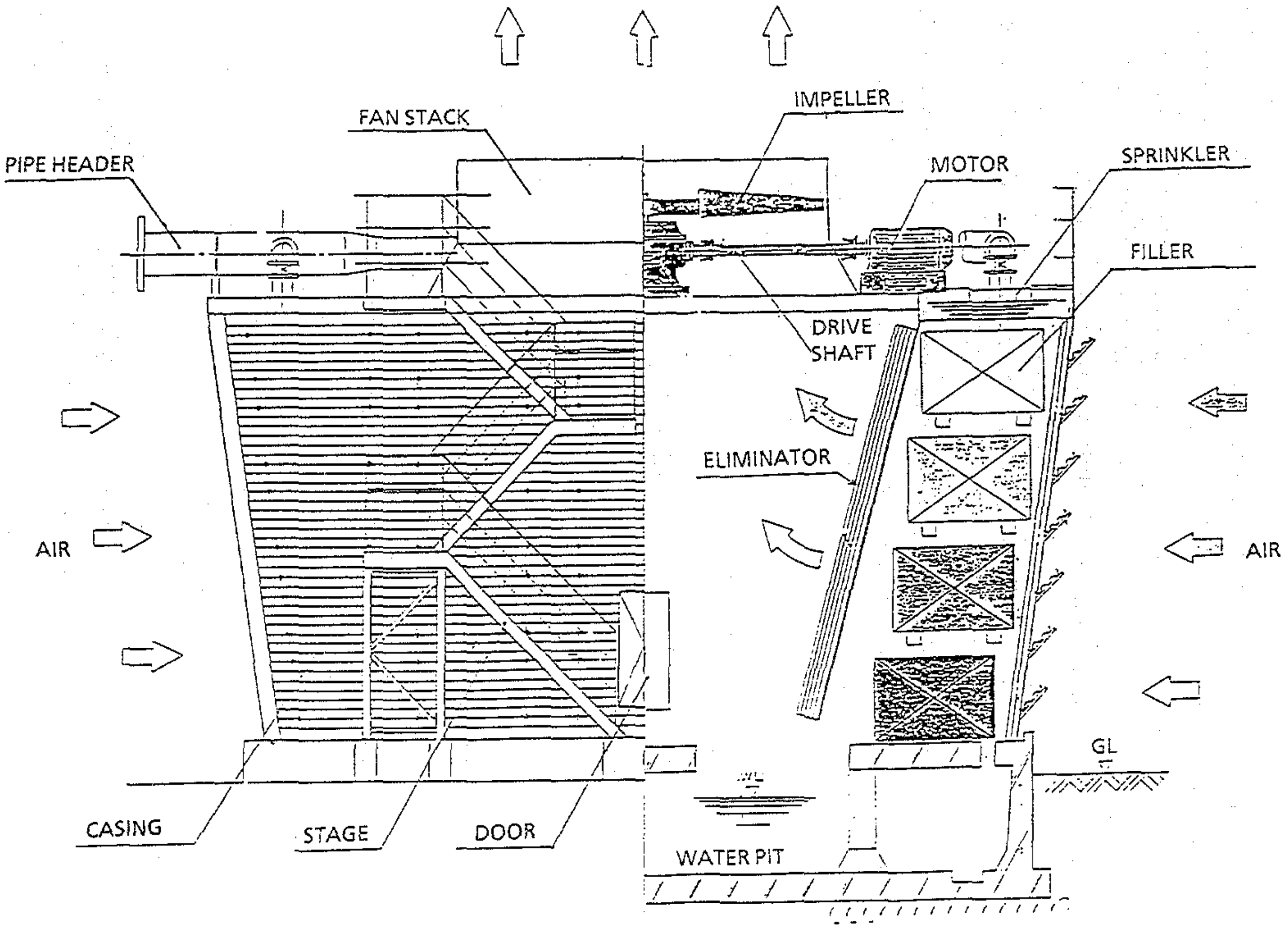


Fig. 11-1-20 Cooling Tower

(2) Boiler Feed Water Plant

1) System

Boiler Feed Water system flow is shown in Fig. 11-1-21.
Main source of boiler feed water is steam condensate recovered from each plant and industrial water is made up for evaporation and blow-down loss during circulation. Two kinds of ion exchangers are provided in order to absorb cations such as Na^+, Ca^{++}, Mg^{++} and anions such as Cl^-, SO_4^{--} in the feed water.
Ion exchangers are periodically regenerated by hydrochloric acid and caustic soda.
A small amount of carbon dioxide and oxygen dissolved in the water is also removed in a stripper and deaerator.

2) Basic Design Data

i) No. of trains : Three

ii) Capacity : 530 t/h train

iii) Cation exchanger

a) Type : Strong acid cation exchange resin
b) No. of unit : Two/train
c) Capacity : 380 m^3/h·unit
d) LV : 50 m/h
e) Regeneration cycle : 4 hours

iv) Anion exchanger

a) Type : Strong base anion exchange resin
b) No. of unit : Two/train
c) Capacity : 380 m^3/h·unit
d) LV : 50 m/h
e) Regeneration cycle : 4 hours

v) Polisher

a) Type : Mixed bed type (Strong acid cation exchanger and strong base anion exchanger)
b) No. of unit : One/train
c) Capacity : 380 m^3/h·unit
d) LV : 50 m/h

vi) Deaerator

b) No. of unit : One/train

c) Capacity : 530 m^3/h

3) Major Equipment

Specifications and the number of units of major equipment are listed in Table 11-1-8. Fig. 11-1-22 shows a sketch of a deaerator.

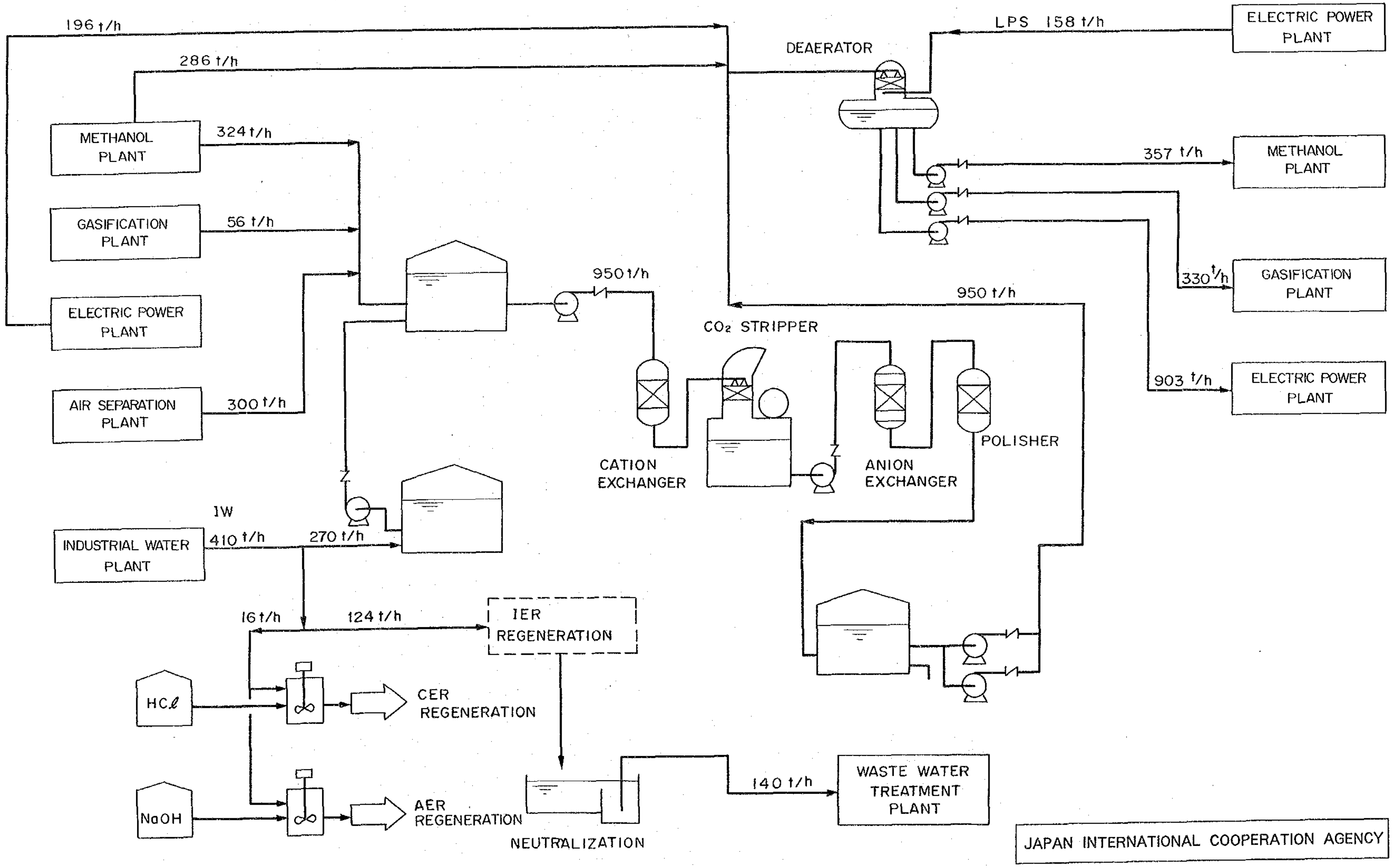


Fig. 11-1-21 Boiler Feed Water System Flow

Table 11-1-8 Major Equipment
(Boiler Feed Water Plant)

Description	Q'ty	Specification
Raw Water Tank	1	300 kl (7.7 mΦ × 7.8 m^H) Type : Cone-roof Material : Carbon-steel
Pure Water Tank (1)	1	700 kl (9.2 mΦ × 9 m^H) Type : Cone-roof Material : Carbon-steel, inside epoxy-lining
Pure Water Tank (2)	1	8,000 kl (14 mΦ × 28 m^H) Type : Cone-roof Material : Carbon-steel, inside epoxy-lining
Deaerator	3	Capacity : 530 m^3/h (3 mΦ × 13 m^L) Weight : 40 tons
Ion Exchange Resins Vessel	15	Capacity : 380 m^3/h (3 mΦ × 3 m^H) Material : Carbon-steel
Raw Water Pump	1	Capacity : 270 m^3/h × 15 m^H Type : Centrifugal Material : Carbon-steel Driver : Motor (22 kW)
Pure Water Pump	12	Capacity : 350 m^3/h × 50 m^H Type : Centrifugal Material : Carbon-steel Driver : 9 unit motor (75 kW) 3 unit engine (75 kW)

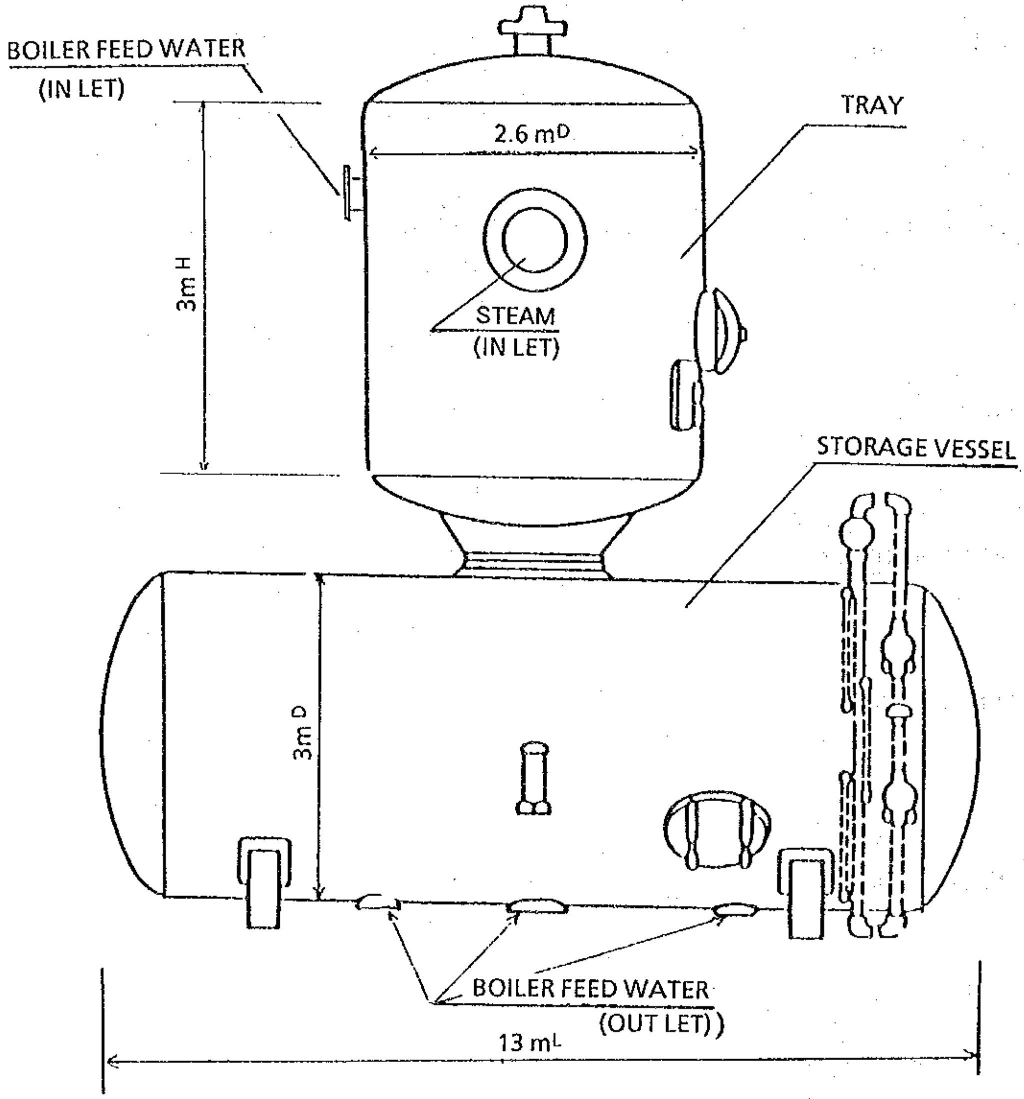


Fig. 11-1-22 Deaertor

(3) Industrial Water and Service Water System

1) System

Industrial water system is shown in Fig. 11-1-23.

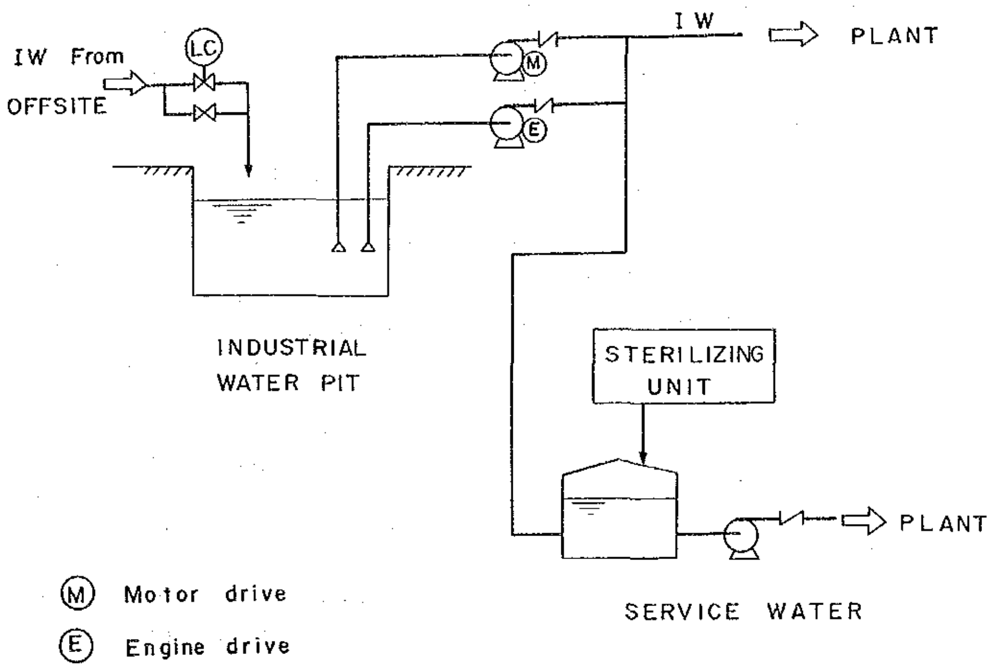


Fig. 11-1-23 Industiral Water Plant Flow

River water is used as the source of industrial water after treatment for removing the muddy materials at the off-site.

At the on-site, a reasonable capacity of water pool is prepared so that continuous water supply can be kept in case of emergency at the off-site.

A small amount of water is sent from this water pool after sterilization for service water which is used for washing hand, face and/or tableware.

2) Basic Design Data

i) No. of trains

Pit	:	One
Industrial water	:	Three
Service water	:	One

ii) Industrial water

a) No. of pumps

Motor driven : 6 (2 units/train × 3 trains)

Engine driven : 3

b) Unit Capacity : 600 m^3/h·pump × 80 m^H

iii) Service water

a) No. of pumps : two

b) Unit capacity : 10 m^3/h·pump × 50 m^H

c) Sterilization : Hypochlorite

Table 11-1-9 Major Equipment
(Industrial/Service Water System)

Description	Q'ty	Specification
Industrial Water Pit	1	3,600 m^3
Industrial Water Pump	9	Capacity : 600 m^3/h × 80 m^H Type : Centrifugal Material : Carbon-steel Driver : 9 unit motor (220 kW) 3 unit engine (220 kW)
Vacuum Pump Unit	3	Capacity Vessel : 2 m^3 Pump : 15 m^3/h × 30 kW Material : Carbon-steel
Service Water Pump	2	Capacity : 10 m^3/h × 50 m^H Type : Centrifugal Material : Carbon-steel Driver : Motor (5.5 kW)
Service Water Tank	1	200 kl (7.7 mφ × 6 m^H) Type : Cone-roof Material : Carbon-steel

(4) Instrument/Service Air System

1) System

Instrument/Service Air Plant Flow is shown in Fig. 11-1-24.
Instrument air is compressed together with service air by air compressors.
Normally, most of compressed air is sent to a dehumidifier where the saturated moisture is removed, and is supplied to each plant via an instrument air holder.
Two units of dehumidifier are to be installed in a train, one of which is normally in operation and the other is being regenerated by regeneration air heated by electric heater.

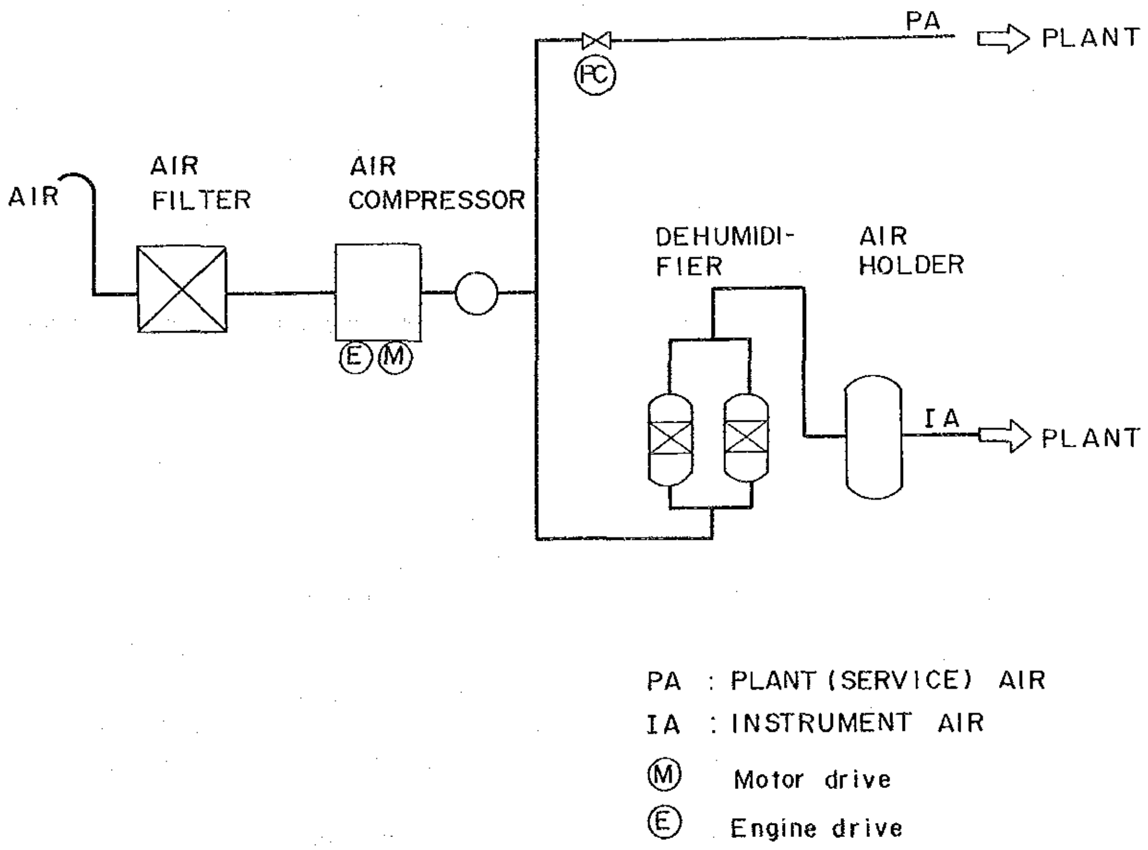


Fig. 11-1-24 Instrument Air Plant Flow

Service air is used for maintenance works during the normal operation and periodical maintenance of each plant.
Normally, some amount of the compressed air from instrument air compressors is directly used as the service air.

2) Basic Design Data

i) No. of trains : Three

ii) Capacity : 3,000 Nm^3/h·train

iii) Air compressor

a) No. of units

Motor driven : 6 (2 units/train × 3 trains)

Engine driven : 3

b) Unit capacity : 1,500 m^3/h·unit

iv) Dehumidifier

a) No. of units : 6 (2 units/train × 3 trains)

b) Unit capacity : 3,000 Nm^3/h·unit

c) Regeneration cycle: 12 hours

d) Regeneration time : 8 hours

3) Major Equipment

Specification and the number of units of major equipment are listed in Table 11-1-10.

Table 11-1-10 Major Equipment
(Industrial/Service Air System)

Description	Q'ty	Specification
Air compressor	9	Capaticy : 1500 $m^3/h \times 7\ kg/m^2G$ Type : Oilless reciprocating Driver : 6 unit motor (180 kW) 3 unit engine (180 kW)
Dehumidifier	6	Capacity : 3,000 Nm^3/h Weight : 4 tons
Air holder	1	Capacity : 10 m^3 (2 mΦ × 4 m^L) Material : Carbon-steel Weight : 4 t

(5) Steam Condensate Recovery System

Steam condensate recovery system is shown in Fig. 11-1-25.

All steam condensate from HP Steam and LP Steam are practically recovered sent into Boiler Feed Water Plant and reused as the boiler feed water.

As shown in Fig. 11-1-25, a part of condensate from the Methanol Plant and all from the Electric Power Plant can be directly put into the deaerators in the Boiler Feed Water Plant, while the others are to be sent to the ion exchange process.

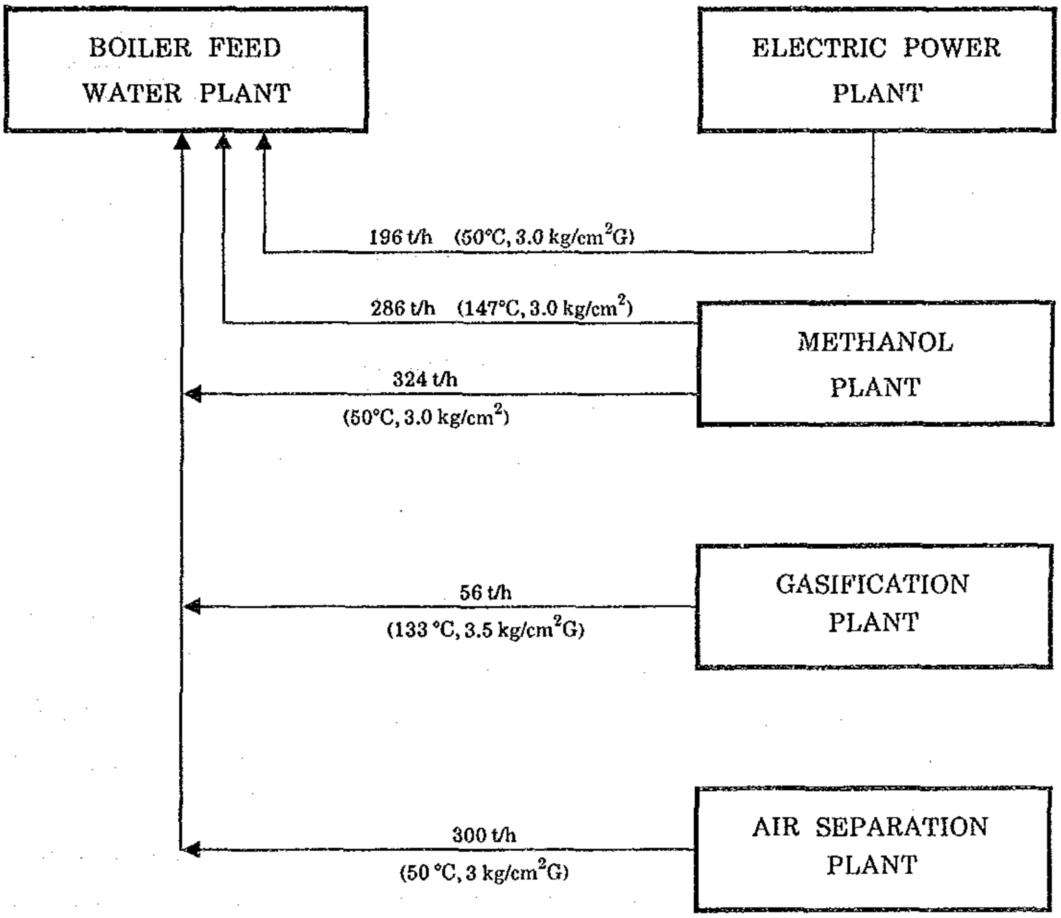


Fig. 11-1-25 Steam Condensate Recovery System

(6) Others

1) Fuel Gas System

Fuel gas balance is shown in Fig. 11-1-26.

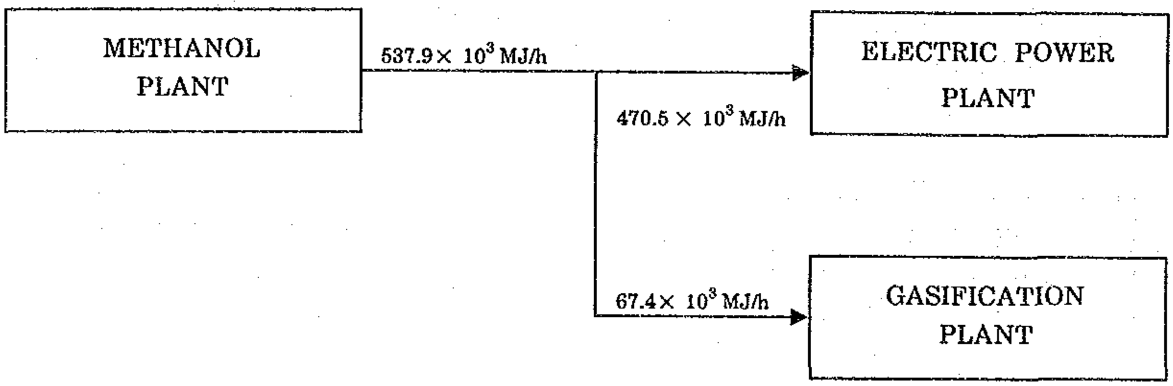


Fig. 11-1-26 Fuel Gas Balance

Fuel gas which is by-produced in the methanol plant is sent to the Coal Gasification Plant and to the boiler.

Other fuel gas such as LPG shall be prepared for temprorary use for the start-up of the gasifier of Coal Gasification Plant.

2) Fuel Methanol System

Fuel methanol is prepared for the start-up of the Coal Gasification Plant, the fluidized bed combustion boiler and for diesel engines of a fire water pump, cooling water pump, boiler feed pump, industrial water pump and air compressors which are operated in case of emergency in Boiler and Electric Power Plant.

If it is impossible to receive electricity from the outside, engine driven generators shall be installed. Fuel methanol is stored in cone roof type tanks in the tank yard.

3) Nitrogen System

Nitrogen system is shown in Fig. 11-1-27.

Nitrogen is necessary for purging the combustible materials in equipment and piping at start-up and shut-down stage.

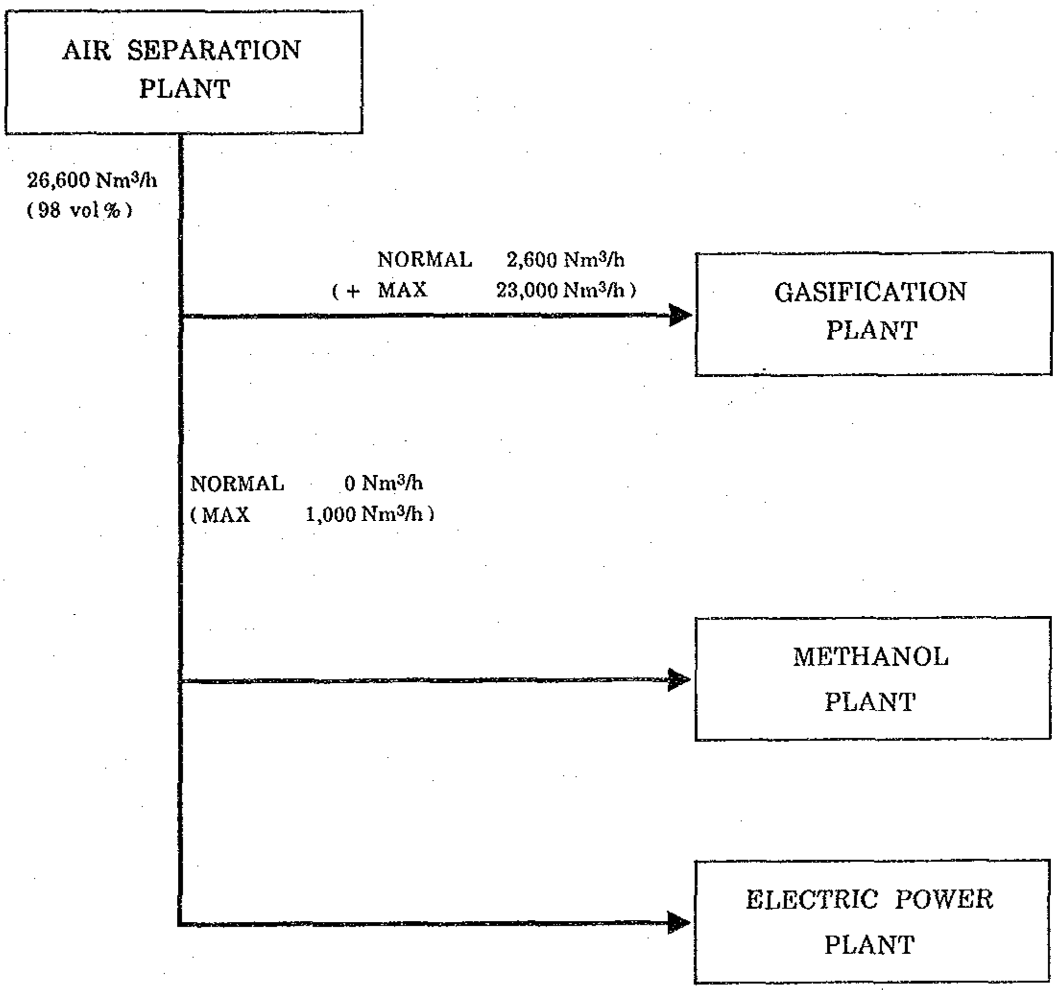


Fig. 11-1-27 Nitrogen System

11-1-6 Product Storage

Product Storage consists of methanol storage tanks and methanol delivery pumps. In addition, other tanks are to be installed in the tank yard for the storage of fuel, lubricating oil and chemicals.

(1) *Methanol Storage Tank*

Product tank capacity has been decided as per the security analysis of supply mentioned in Section 11-2-3.

Three (3) dome roof tanks with a storage capacity of 15,000 kℓ each, which corresponds to 2.7 day full production, are to be installed in the tank yard.

Methanol storage tanks are to be used in the cycle of product receiving from the Methanol plant, product quality inspection, and product delivery. As a whole system, three methanol tanks will be operated in the mode shown in Fig. 11-1-28.

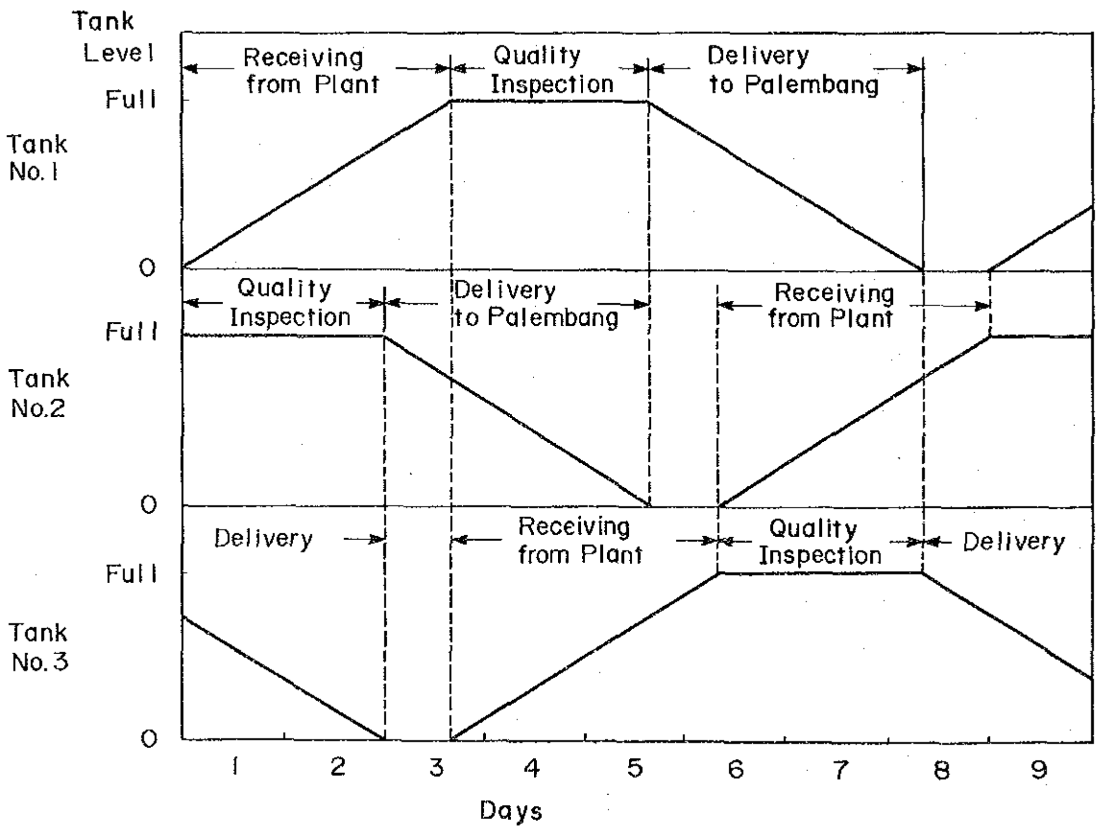


Fig. 11-1-28 Methanol Tanks Operation Mode

1) Any one of three tanks is normally full waiting for inspection of methanol quality.

2) Either of the other two is under delivery to the Shipping Terminal in Palembang.

3) The third tank is for receiving product from the Methanol Plant.

Preparing for unexpected pipeline trouble, the second and third tanks are to have empty margin equivalent to approximately one tank volume.
Methanol delivery system is to be equipped with total four (4) pumps with a capacity of 80 $m^3/h \times 130$ m each. At the final stage, three (3) pumps will be normally in operation and one pump will be the common spare for the rest.

(2) Other Storage Tanks

In addition to the above, other storage tanks are to be installed in the liquid storage tank yard as follows.

Fuel Methanol	:	10,000 kℓ × 1
Lubricant Oil	:	500 kℓ × 1
LPG	:	10,000 kℓ × 1
Chemicals	:	100 kℓ × 5

11-1-7 Pollution Control and Safety Systems

In order to prevent enviornmental pollution and to maintain safety of the coal gasification complex, waste water treatment system, flare stack and fire fighting facilities are to be planned.

(1) Waste Water Treatment Facilities

Two kinds of waste water exist, i.e. one is clean and the other is dirty waste water.

1) Clean Waste Water Treatment

i) System

Clean waste water from each plant is gathered and sent to the pit reservoir equipped with cooling tower as shown in Fig. 11-1-29.

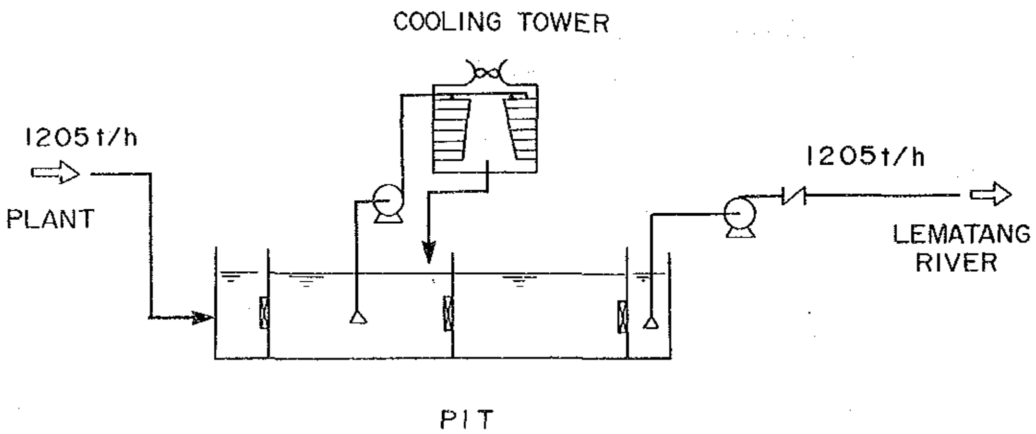


Fig. 11-1-29 Clean Waste Water Treatment

In the pit reservoir, the waste water is cooled down to 32°C for the prevention of thermal pollution and sent to the Lematang riverside for discharge.

ii) Basic design data

a) Amount of clean waste water

Coal Gasificatoin Plant	:	210 t/h
Air Separation Plant	:	50 t/h
Electric Power Plant	:	55 t/h
Cooling Water Plant	:	890 t/h
Total	:	1,205 t/h

2) Dirty Waste Water Treatment

i) System

Dirty waste water treatment system flow is shown in Fig. 11-1-30.
Waste water gathered from each plant flows into the API separator where oil contained in the water is reduced to several ppm.
After oil separation followed by neutralization, the water is introduced to the activated sludge treatment unit where BOD is reduced to 120 ppm.
After that, the water is sent to the sedimentation coagulation unit where SS in the water is reduced to 200 ppm.
Treated water is led into a pit and the water quality shall be inspected before discharge to the Lematang river.
It should be noticed that the pit is necessary in order to prevent accidental discharge of methanol.

ii) Basic design data

a) Amount of dirty waste water

Methanol Plant	:	31 t/h
Electric Power Plant	:	36 t/h
Boiler Feed Water Plant	:	140 t/h
Total	:	207 t/h

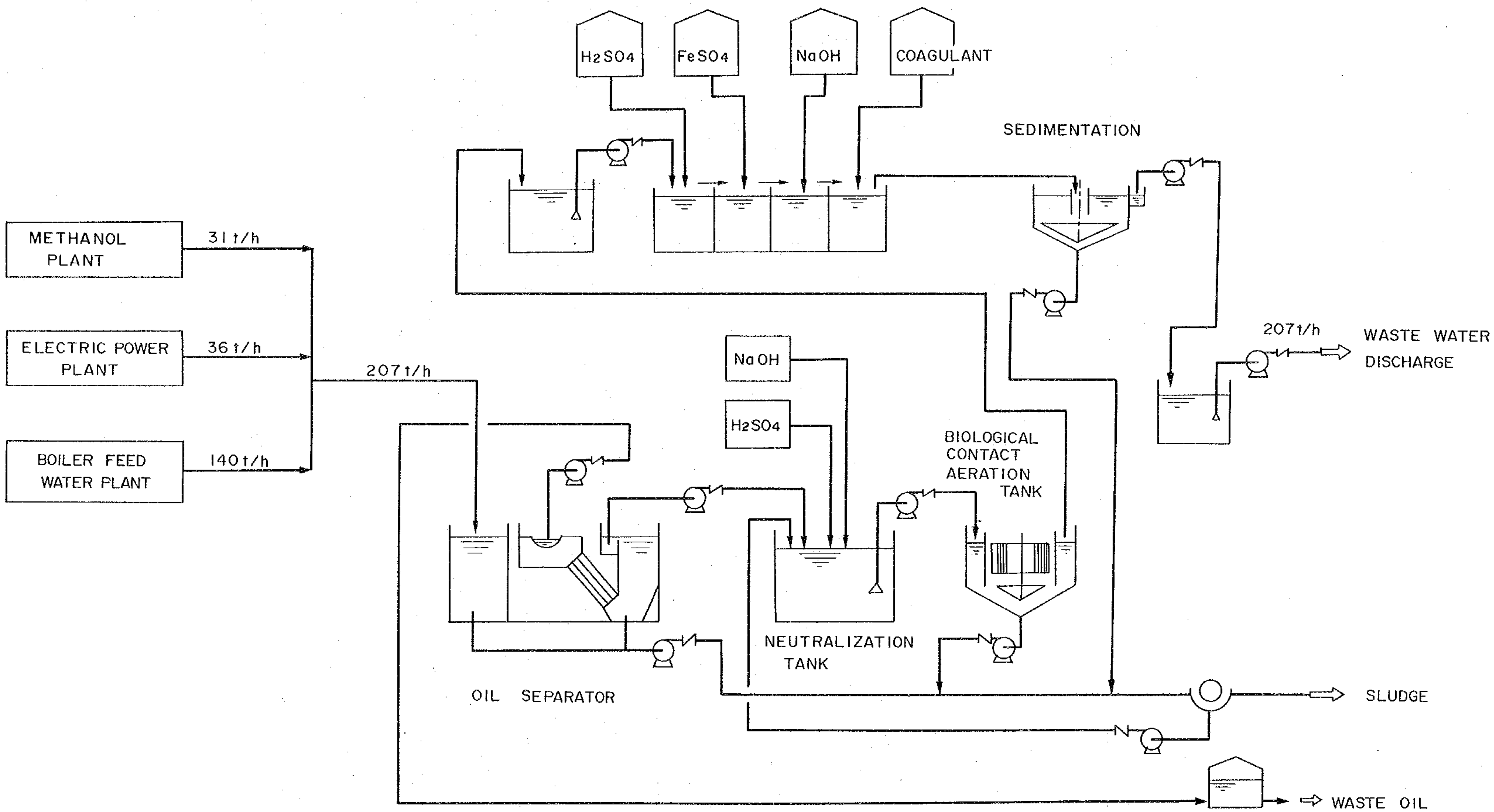


Fig. 11-1-30 Waste Water (Dirty) Treatment Flow

(2) Flare Stack

1) System

Flare System is shown in Fig. 11-1-31.
This facility is operated mainly at the start-up and shut-down stage of Methanol Plant to burn the purge gas from the Plant.
It is also operated automatically in the case of emergency shut-down of Methanol Plant.

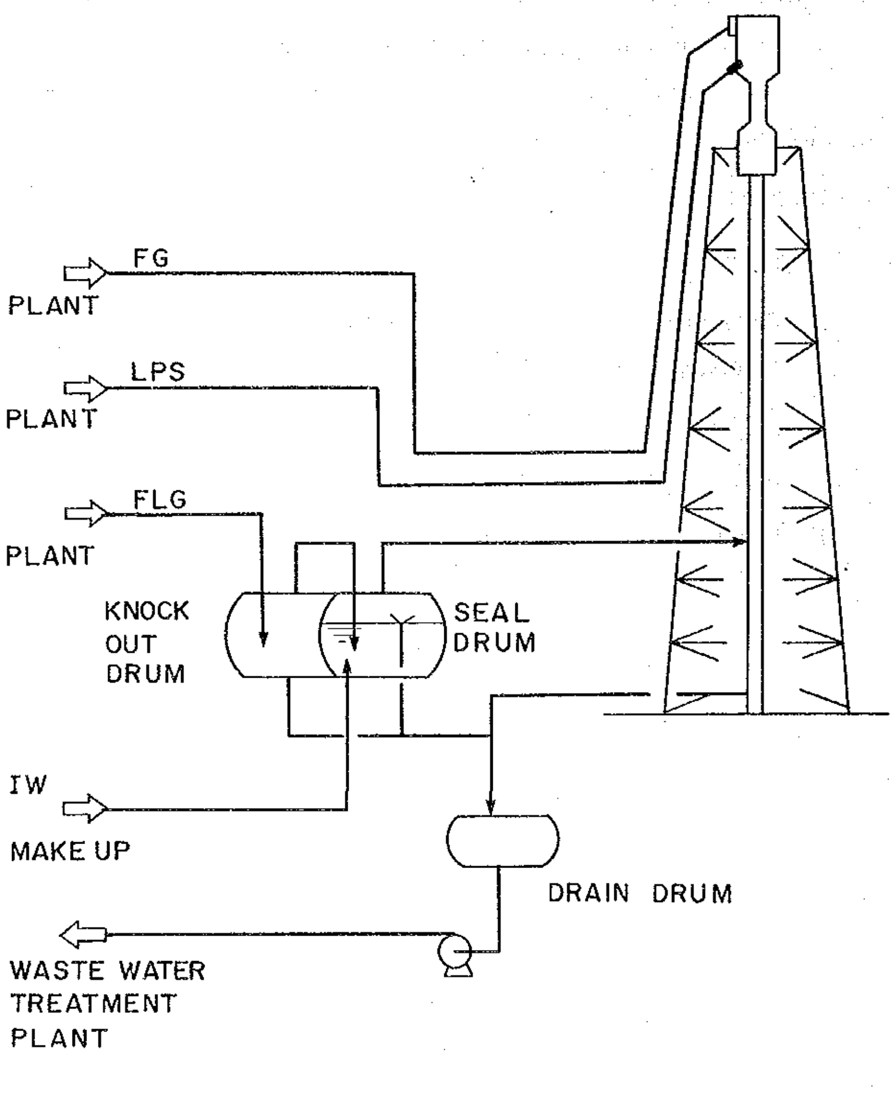
2) Basic Design Data

i) Flare gas

a) Flow rate : 151,000 Nm^3/h
b) Temperature : 40°C

ii) Basic dimension

a) Diameter : 940 mmΦ
b) Height : 64 m



FG : FUEL GAS (PILOT FUEL GAS)

FLG : FLARE GAS

IW : INDUSTRIAL WATER

Fig. 11-1-31 Flare System

(3) Fire Fighting Facility

1) Fixed Fire Fighting System

A fixed fire fighting system is to be provided as shown in Fig. 11-1-32.
The alcofoam fire fighting system is used to extinguish methanol fire while fire water is applied to the general fire such as coal fire or building fire.
Necessary numbers of alcofoam solution hydrant are arranged around Methanol Plant and an alcofoam system is set up by the side of the Tank Yard.
This alcofoam system supplies alcofoam solution to the hydrants and air foam chambers equipped to methanol storage tanks.
Water hydrants are arranged principally around Coal Gasification Plant, Coal Handling Area, Boiler and Electric Power Generation Plant and other buildings.
Fire water is supplied from the industrial water pool by fire pumps which are driven by motors or diesel engines.

2) Fire Engine

The following fire engines are to be stationed in the fire engine house.

i) Fire engine : one
ii) Chemical fire engine : one
iii) Universal water tower fire fighting truck : one
iv) Alcofoam tank lorry : one

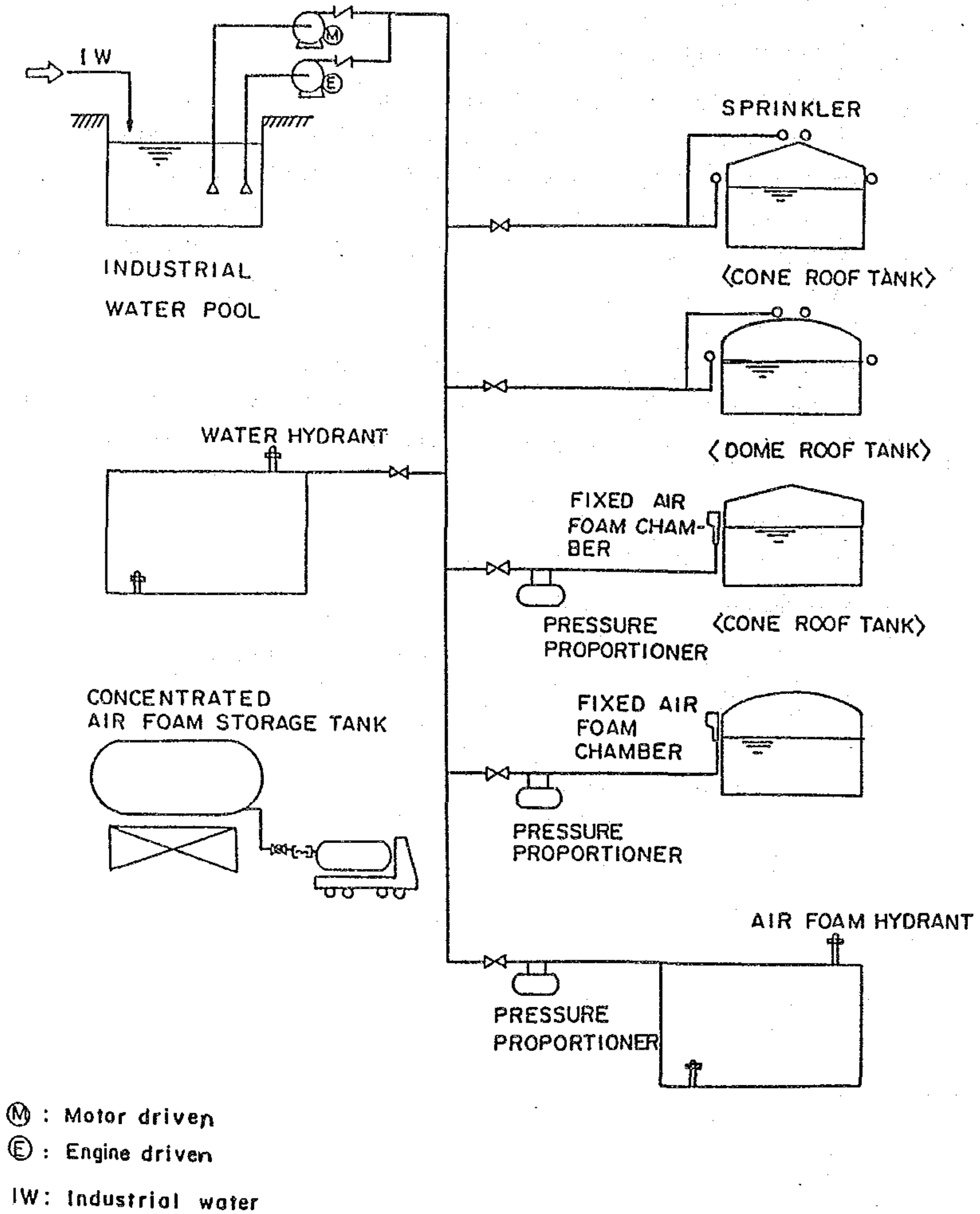


Fig. 11-1-32 Fire Fighting System Flow

11-1-8 Auxiliary Facilities

Auxiliary Facilities include Interconnection Pipelines, Office, Laboratory, Maintenance Workshop and Warehouse, and Training Center.

(1) Interconnection Pipelines

Interconnection Pipelines are installed based on the full capacity of the gasification complex at the first stage of the construction schedule but branch pipeline installation is divided in three stages from an economical standpoint of view.

Interconnection Pipelines List is shown in Table 11-1-11.

Table 11-1-11 Interconnection Pipeline List

Service	From	To	Size(A) x Length(m)	Weight (t)	P (kg)	T (°C)
HPS	Gasification	Power Station	300 x 150	440	75	290
	Power Station	A/S, Methanol	500 x 700, 650		65	480
LPS	Power Station	Gasfication	500 x 150	230	3.5	146
		W/T, A/S, Methanol	1000 x 800, 250 x 200			
FG	Methanol	Power & Gasfication	600 x 650	30	3.5	40
N_2	A/S	Gasfication	300 x 650	60	6	A.T
		Methanol	65 x 550			
O_2	A/S	Gasfication	300 x 550	30	10	A.T
SG	Gasification	Methanol	900 x 400 x 3	90	2.5	32
CO_2	Methanol	Gasfication	150 x 350	15	15	32
IA	A/S	each plant	200 x 600, 90 x 550 etc.	35	5	A.T
Flare	Methanol	Flare	600 x 800 etc.	240	max. 34	40
CW	W/T	C/T	800 x 250	3,000	8	A.T
	C/T	each plant	1200 x 1800 etc.		8	32
IW	W/T	each plant	400 x 100 etc.	65	8	A.T
BFW	W/T	each plant		100		125
SC	each plant	W/T	350 x 700 etc.	85	3	50
FW	W/T	each facility	300 x 2000	100	10	A.T
WW	each plant	W/T	300 x 350 etc.	20	3	
SW	W/T	each plant	200 x 450 etc.	20	3	A.T
Methanol	Methanol	Tank yard	150 x 350	10	3	A.T

(2) Office

Fig. 11-1-33 shows a layout of common buildings such as the administration office, the dining hall, the laboratory, the fire station, the gate house, the maintenance office, and the warehouse/workshop.
The administration office shown in Fig. 11-1-34 of ATTACHMENT 11-1 shall consist of necessary office rooms for members working in Administration, Marketing, Security & Safety and Production Control Departments. In addition, the administration office is to be provided with a computer room, a telephone and telex room, a typing and copy machine room, and an air conditioning and hot water supply system.
Fig. 11-1-35 and Fig. 11-1-36 of ATTACHMENT 11-1 show sketches of the dining hall and the gate house. (Fig. 11-1-34 through 40 are shown in ATTACHMENT 11-1.)

(3) Laboratory

On-line analyzers are installed in plants for continuous and automatic analyses of flowing materials in process.
However, properties of raw materials and final products, utilities and waste are analyzed and examined in the laboratory periodically or in case of necessity.
Fig. 11-1-37 of ATTACHMENT 11-1 shows layout of the laboratory building.
Table 11-1-12 shows equipment list to be installed in the laboratory.
Main analysis items in the laboratory are as follows.

1) Coal

i) Proximate analysis

a) Moisture (Mo.)
b) Volatile matter (V.M)
c) Ash

ii) Ultimate analysis

a) Carbon
b) Hydrogen
c) Nitrogen
d) Sulfur

iii) Ash

a) Composition
b) Fusion temperature

iv) Gross calorific value

2) Methanol

i) CH_3OH
ii) Free acid
iii) 64 - 66°C fraction
iv) Others

3) Water

i) River water

a) pH
b) Total dissolved solids (TDS)
c) Electric conductivity
d) Silica
e) Hardness
f) Alkalinity
g) Fe

ii) Boiler water

a) pH
b) Electric conductivity
c) Silica
d) Hardness
e) Chemical oxygen demand (COD)
f) Dissolved oxygen (DO)

iii) Waste water

a) pH
b) Electric conductivity
c) Biological oxygen demand (BOD)
d) Chemical oxygen demand (COD)
e) Suspended solids (SS)
f) Dissolved oxygen (DO)
g) N-hex
h) Total organic carbon (TOC)

4) Flue Gas

i) NOx

ii) SOx

iii) Dust

5) Solid Waste Composition

i) Slag

ii) Dust

iii) Ash

Table 11-1-12 Major Equipment in Laboratory

Item	Quantity
X-ray fluorescence analyzer	1
Autoclave	1
Rectificator	1
Gas chromatograph	4
Spectro photometer	1
Potentiometric titrator	2
Refrigerator	2
Engler distillator	1
Total sulfur analyzer	1
Volatile matter meter	1
Ash fusion temperature meter	1
Carolimeter	1
V.M meter	1
Infrared absorption analyzer	1
Hard grobe tester	1
Particle size analyzer	1
Specific gravity meter	2
Electric furnace	2
pH meter	3
DO meter	1
COD meter	1
BOD meter	1
Electric conductivity meter	3
TOC meter	1
SS meter	1
NOx meter	1
SOx meter	1
Dust meter	1
Atomic absorption spectro photometer	1

(4) Workshop and Warehouse

1) Maintenance Plan

Because the plant site is located far from equipment manufacturers and support industry has not yet been developed in Banko area, it will take a long period to carry out a large amount of maintenance work or special repair work. Therefore, maintenance workshops and warehouses are to be constructed so that most maintenance and repair works can be performed within the plant.

In order to realize an efficient maintenance system, attention should be paid to the followings.

a) Adopting equipment and components with standard specification as much as possible, instead of special specification

b) Avoiding severe process conditions

c) Installation of stand-by spares for important equipment and components which has possibility of corrosion, break down, etc.

d) Preparation of one package spares in order to reduce field maintenance time.

Two workshops will be planned. One is a mechanical workshop and the other is an electrical and instrument workshop. Each workshop includes warehouse for its own use. Fig. 11-1-38 through Fig. 11-1-40 of ATTACHMENT 11-1 show the outlines of Maintenance Office, Mechanical Workshop/Warehouse, and Electrical and Instrument Workshop/Warehouse respectively.

In the workshop, the following maintenance work and inspection work shall be carried out as daily maintenance including pre-maintenance and periodical annual maintenance.

i) Assembly of one package spares and complete spare.
ii) Cleaning and adjustment of instrument.
iii) Thorough overhaul of machinery.
iv) Exchange failed parts of instrument and electrical equipment.
v) Prefabrication of simple pipe arrangement.

Special maintenance works such as non-destructive inspection using X-ray or γ-ray are to be carried out by outcontractors from Palembang or Jakarta being coordinated by mechanical maintenance staff.

2) Mechanical Workshop and Warehouse

i) Mechanical Workshop

Table 11-1-13 shows item and quantity of main machines and tools to be arranged in the Mechanical Workshop.

Table 11-1-13 Major Equipment in Mechanical Workshop

Item			Quantity
(1) Machine Tools			
Lathe			1
Swing over bed:		430 mm	
Swing over carriage:		230 mm	
Lathe			1
Swing over bed:		490 mm	
Swing over carriage:		260 mm	
Lathe			1
Swing over bed:		820 mm	
Swing over carriage:		500 mm	
Vertical Lathe			1
Table diameter:		1,500 mm	
Max. turning diameter:		1,900 mm	
Universal Milling Machine			1
Maximum table movement:		860mm × 355mm × 450mm	
Radial Drilling Machine			1
Column sleeve - Main spindle distance:		465 mm - 2,125 mm	
Main spindle - Basement surface distance:		610 mm - 1,890 mm	
Bending Machine	Capacity:	1,250 × 1.6 t	1
Bending-roll Machine	Capacity:	2,500 × 13 t	1
Shearing Machine	Capacity:	10 t x 2,000 mmℓ	1
Lapping Machine	Effective diameter:	1,070ϕ	1
Drilling Machine	Drilling ability:	10ϕ	2
Grinding Machine	Grinder diameter:	150, 205, 355 mm	3
Universal Tool and Cutter Grinder	Swing over table:	250 mm	1
Argon Arc Welder	D.C range:	20 - 300 A	1
Arc Welder	D.C range:	60 - 300 A	2
Roof Crane		10 t	1
Others			
(2) Testing Equipment			
Balancing Machine			1
Vibration Meter (Portable)			2
Ultrasonic Reflectscope			1
Ultrasonic Thicknessmeter (0.8 - 179.8 mm)			1
Magnetic-field Test Equipment			1
Safety Valve Test Equipment			1
Metallurgical Microscope (35X - 2000X)			1
Others			

ii) Mechanical Warehouse

Following materials shall be stored in the Mechanical Warehouse.

a) Package spares or complete spares: Storage amount 100%

b) Spare parts for exchange on daily or annual maintenance (Reused as spares after repair. ex. shaft or impeller of small rotating equipment.) 200%

c) Consumable spare parts such as gasket, bolt, nut, bearing, etc. 200%

d) Spare parts for insurance (Unnecessary for daily or annual maintenance and used only at unexpected damage. ex. rotar for large sized turbine, compressor)

Amount of parts built-in the facililties:

One: 100%

More than two: 50%

e) Consumable such as welding rods: 1 year use

f) Materials for insulation: ditto

g) Materials for painting: ditto

h) Catalyst: ditto

i) Chemicals: ditto

j) Lubricant: ditto

3) Electrical and Instrument Workshop and Warehouse

i) Electrical and Instrument Workshop

Table 11-1-14 shows item and quantity of main equipment to be provided in the Electrical and Instrument Workshop.

ii) Electrical and Instrument Warehouse

Following materials shall be stored in the Electrical and Instrument Warehouse.

a) Package spares or complete spares: Storage amount 100%

b) Spare parts for instrument such as transmitter, positioner, orifice plate, control valves, pressure gauge, etc.: 200%

c) Spare parts for electrical equipment: 200%

d) Materials for field work such as cable, copper tube, etc.: 1 year use

Table 11-1-14 Major Equipment in Electrical and Instrument Workshop

Item		Quantity
(1) Testing Equipment	Standard pressurizer	3
	Apparatus for leakage test	1
	Hydraulic pressurizing pump	1
	Oil bath	1
	Water bath	1
	Refrigerator	1
	High voltage tester	1
	Vibration analyzer for electric equipment	1
	Relay checker	1
	Air compressor	1
	Others	
(2) Measuring Equipment	Standard voltage meter, ampere meter, watt meter	5
	Standard thermometer	3
	Manometer	3
	Precise direct current potentiometer	1
	Precise wheatstone bridge	1
	Standard resistor	5
	Synchroscope	2
	Digital multimeter (V, A, Ω)	3
	Electrical adjuster	2
	Direct current power source	3
	Digital watt meter	1
	Thermometer	3
	Others	
(3) Machine and Tool	Bench drilling machine	1
	Bench grinding machine	1
	Cut-off machine	2
	Pipe bending machine	1
	Welding machine	1
	Others	

(5) Training Center

Employees of the key plants such as the Gasification Plant, the Methanol Plant are to be trained overseas and in the training center located in the laboratory building shown in Fig. 11-1-37 of ATTACHMENT 11-1.
The following equipment is to be installed in the training center to provide basic training.

i) Visual & audio equipment

Because lectures on plant technology are usually difficult and uninteresting to inexperienced personnel, basic training should integrate visual and audio systems such as slide shows, movies, videos, etc. as much as possible.

ii) Cutaway model of equipment & sample

iii) Process simulator

Since wrong operation in an actual plant brings troubles with the plant, it is risky to give inexperienced personnel operation training directly at an actual plant.
Instead, training on basic operation against possible trouble with instruments or equipment using panel based process simulator which provides basic unit operations such as distillation, heating furnace, compression, etc.

As for foremen, operators or technicians for analysis or maintenance, training using actual equipment in the laboratory or the workshiop will be carried out after basic education at the training center.

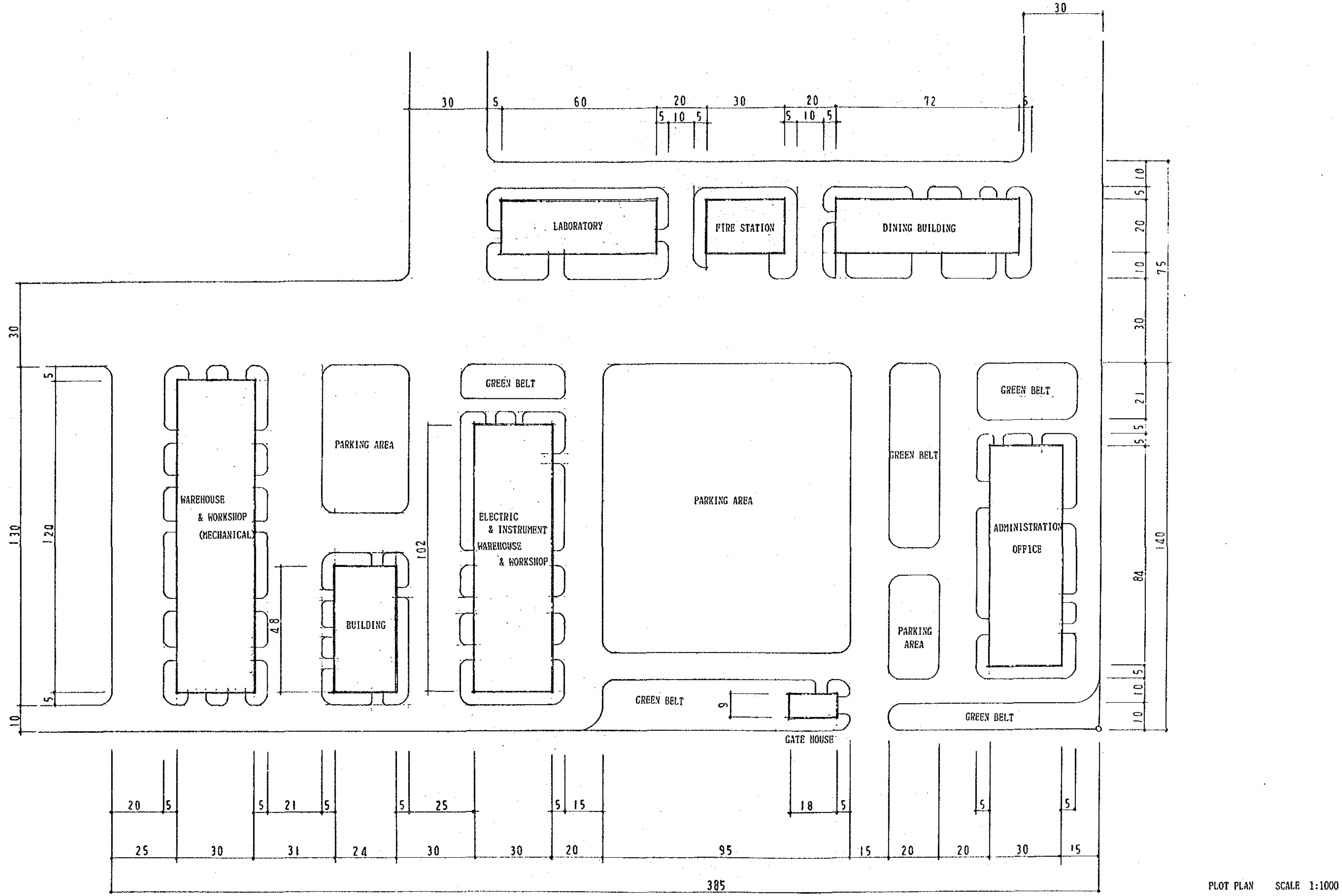


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Fig. 11-1-33 Administration & Maintenance Area

11-2 OFF-SITE FACILITIES

Off-site facilities include the Belt Conveyor for coal transportation from the coal mining area to the plant site, the Product Pipeline from the plant site to Palembang, the Methanol Shipping Terminal in Palembang, the Water Intake system at the Lematang riverside and Waste Disposal system.

11-2-1 Belt Conveyor System

(1) System

The belt conveyor route was tentatively determined by selecting relatively flat land or land with mild gradient as shown in Fig. 11-2-1.

After received in a 350 m^3 bunker hopper, the mined coal is crushed into appropriate size and then carried to the plant site by a single conveyor line. The conveyor extends about 14.2 km from N.W. Banko to Desa Muara Enim crossing roads, small rivers and railways.

The conveyor line is to hold at least 16 m safety distance from main roads. Besides, land is to be acquired by a width of 15 meters along the belt conveyor route, whereas land clearing is to be done at a maximum, i.e. for a width of 10 meters and a depth or height of 1 meter in average including 200 mm thickness gravelling as a maintenance road.

Fig. 11-2-2 through Fig. 11-2-5 show a typical layout, a gallery bridge for crossing a road or railway, a girder bridge for crossing a river, and an underground conveyor.

(2) Basic Design Data

Basic specifications for the Belt Conveyor System are summarized as follows.

1) Coal to be carried : 3,688,000 t/y

2) Operation Hours : 20 h/d

3) Designed Capacity : 620 t/h

4) Belt Width : 900 mm

5) Belt Speed : 180 m/min.

6) Belt Trough Angle : 35°

(3) Major Equipment

The specifications and the numbers of units of major equipment are listed in Table 11-2-1.

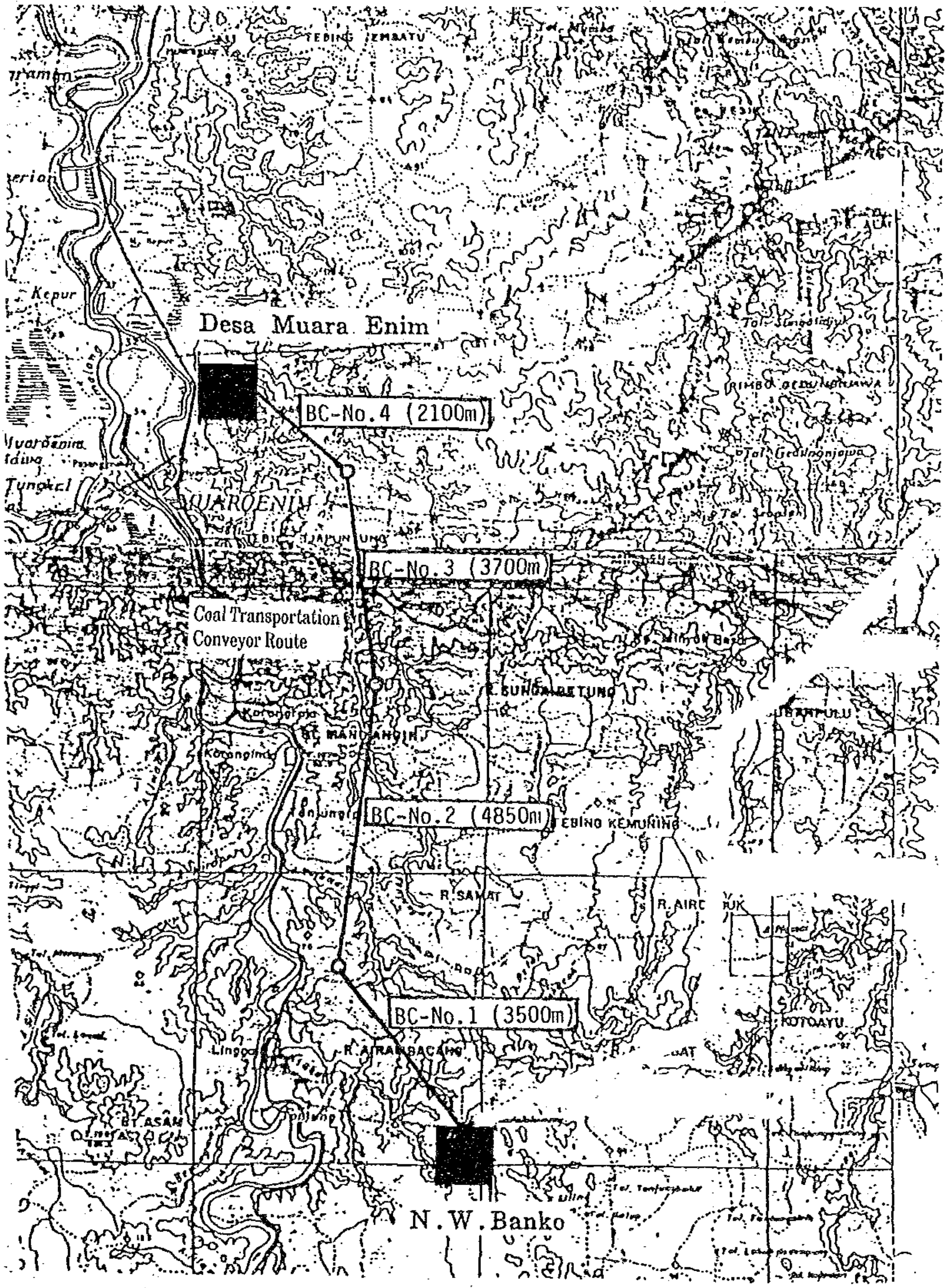

Fig. 11-2-1 Belt Conveyor Route

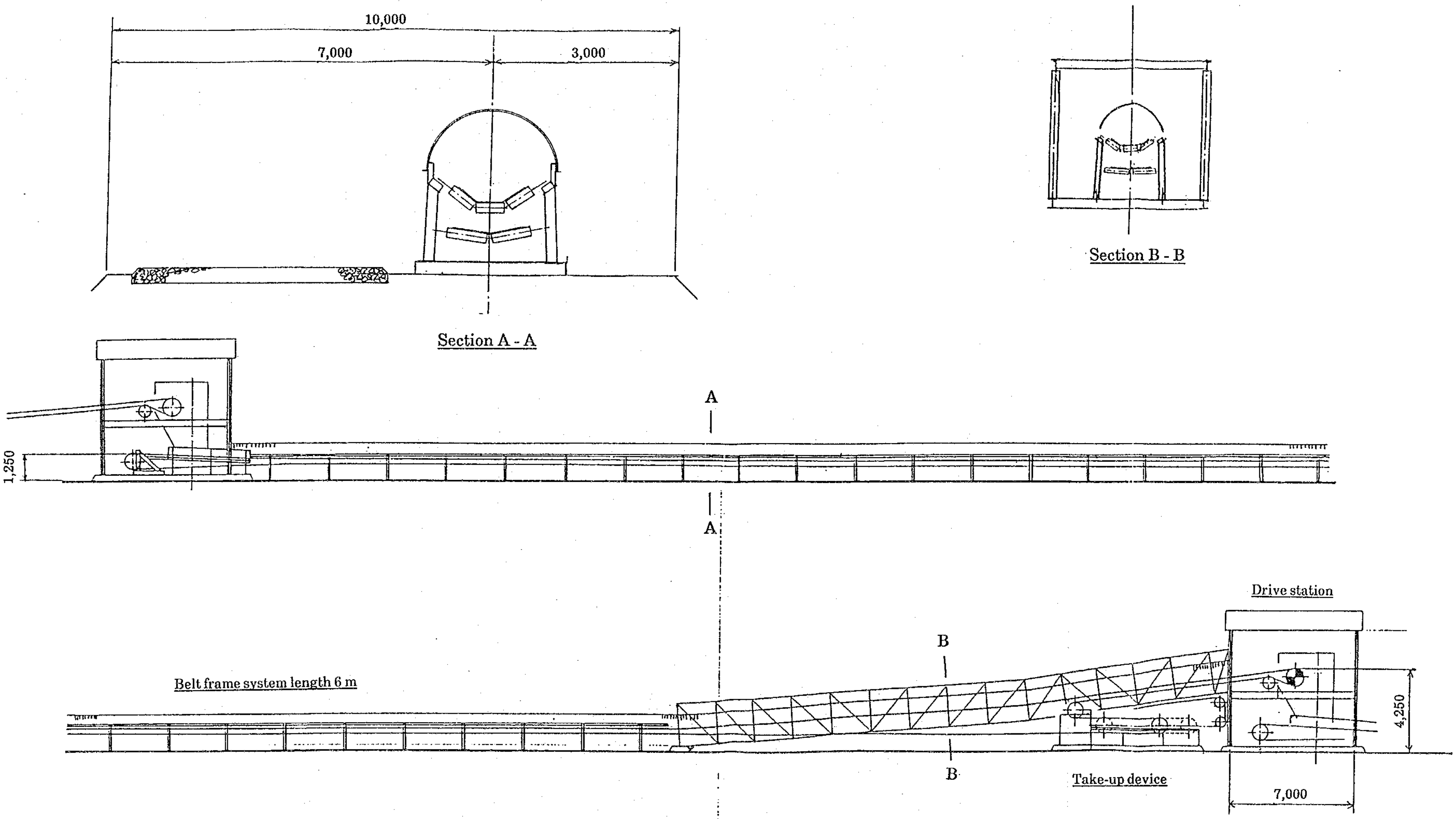

Fig. 11-2-2 Type Layout of Conveyor

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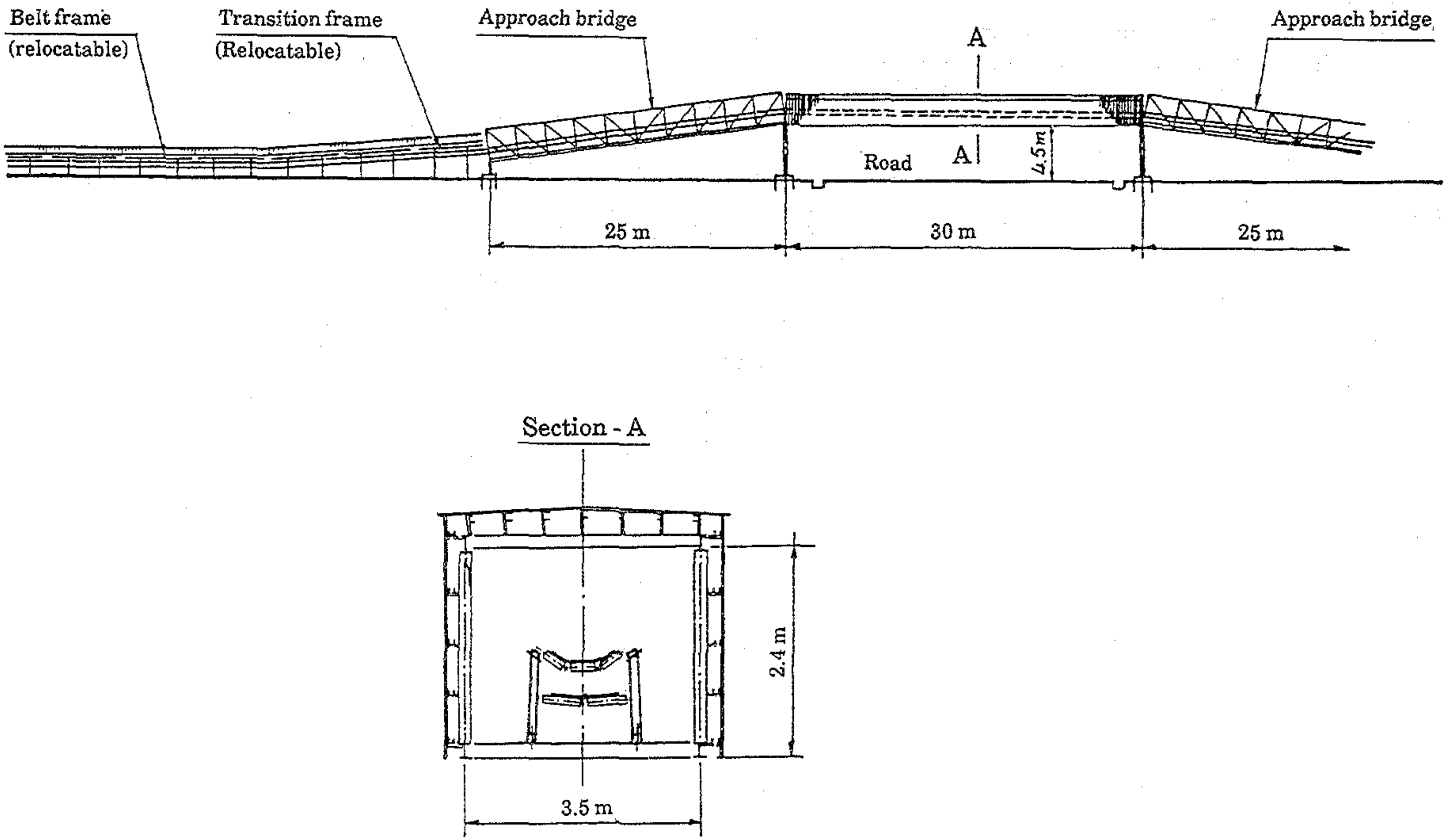

Fig. 11-2-3 Gallery Bridge

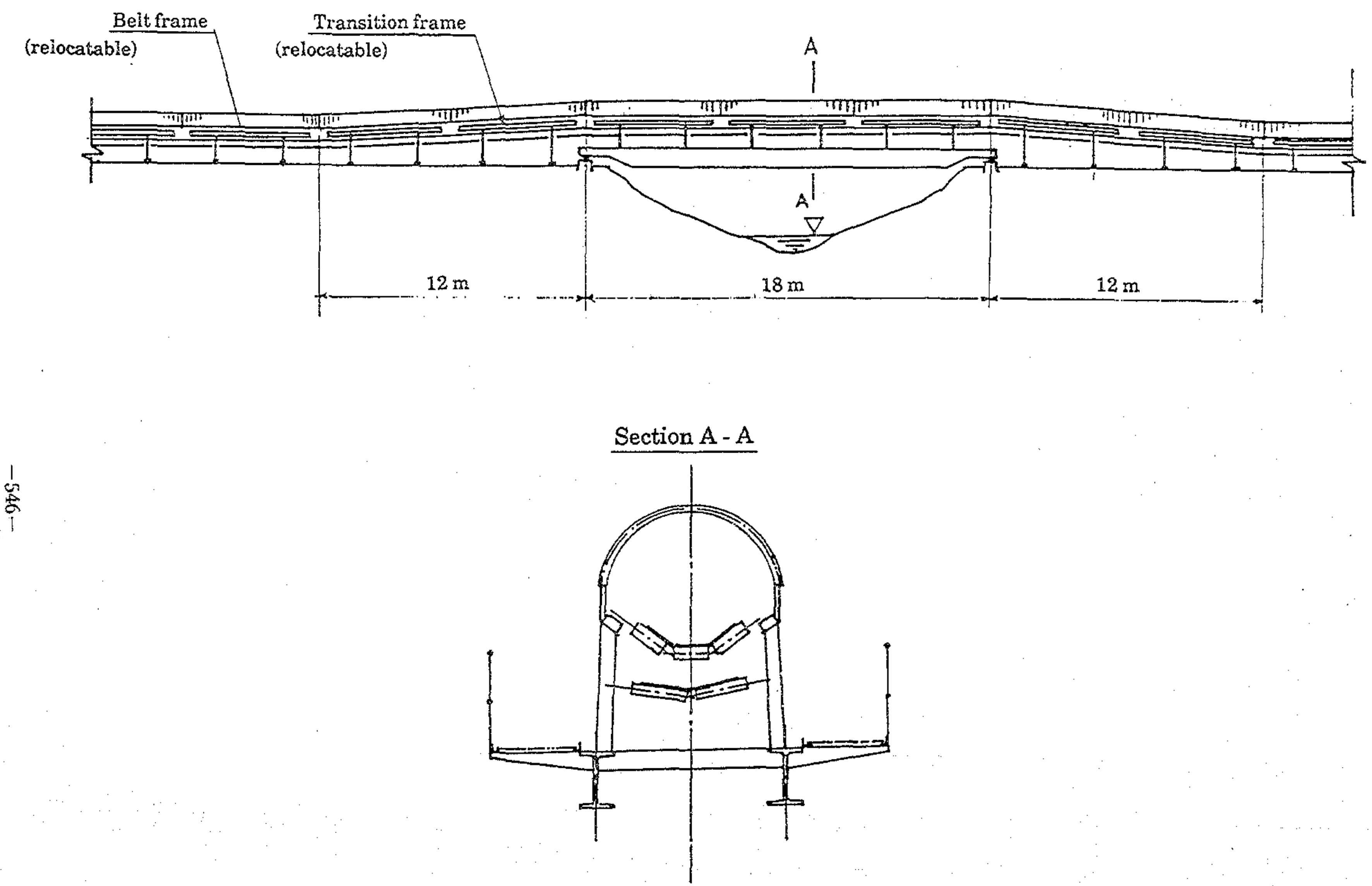

Fig. 11-2-4 Girder Bridge

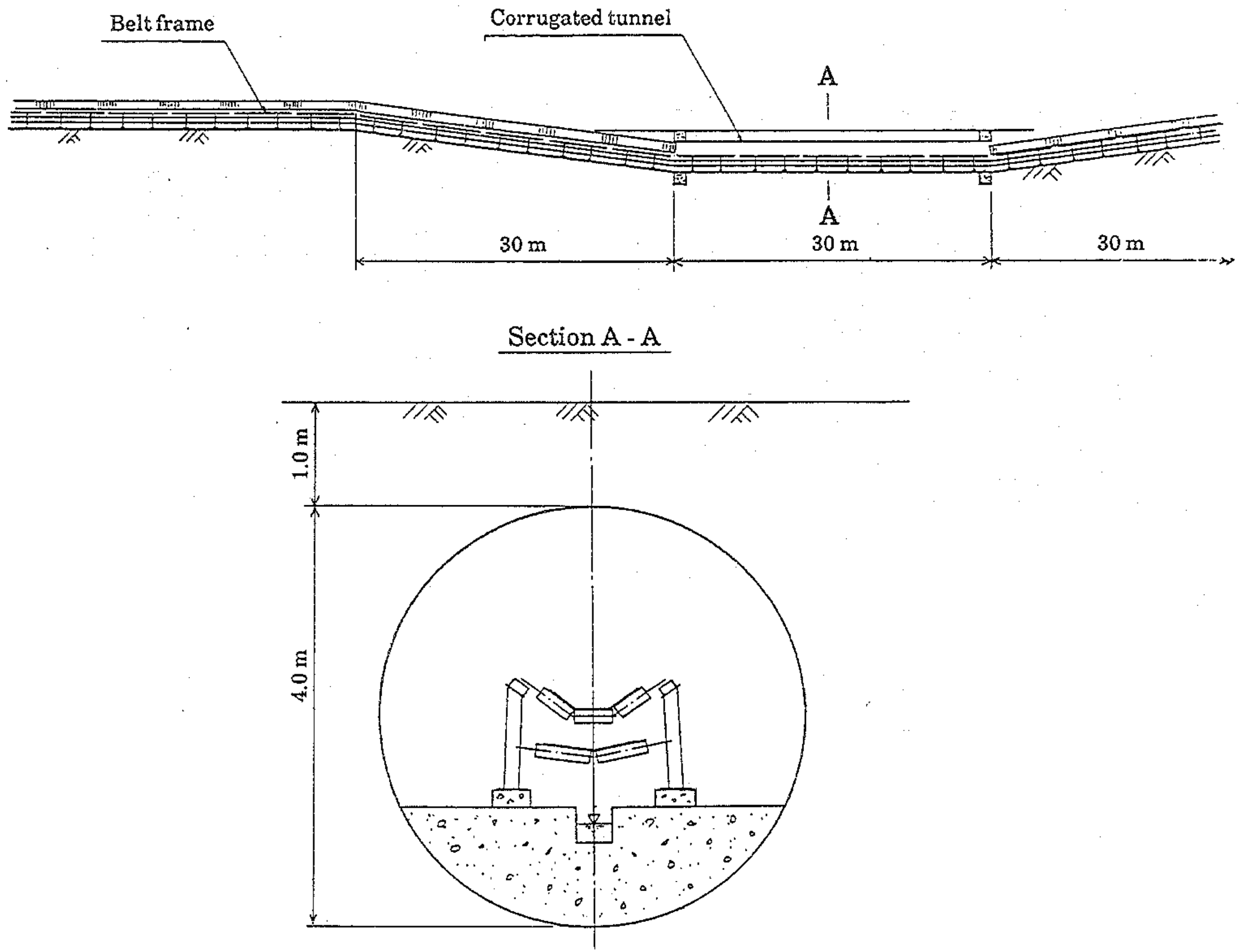

Fig. 11-2-5 Underground Conveyor

Table 11-2-1 Equipment List

Coal : N.W. Banko

Plant : Muara Enim

DESCRIPTION	Q'TY	SPECIFICATION
Bunker hopper	1	350 m^3
Vibrating feeder	3	Max. 400 t/h
Crusher	1	Max. 800 t/h
Belt conveyor No. 1	1	Q = 620 t/h, BW 900, L=3500 m, 2 × 175 kW
Belt conveyor No. 2	1	BW 900, L=4850 m, 3 × 175 kW
Belt conveyor No. 3	1	BW 900, L=3700 m, 2 × 175 kW
Belt conveyor No. 4	1	BW 900, L=2100 m, 2 × 175 kW
Crusher house	1	10 m × 15 m × 3-floors
Gallery bridge above road and railway with two approach bridges	4	Span 30 m × 3.5 m
Girder to cross over the swamp/brook	5	Span 18 m
Corrugated tunnel	2	ϕ4.0 m × 30 m
Transfer station building	4	7.0 m × 8.0 m × 2-floor
Center control building	1	8.0 m × 8.0 m × 1-floor
Electricity distribution building	1	6.0 m × 10.0 m × 1-floor
Local electricity distribution building	4	4.0 m × 6.0 m × 1-floor
Volume of excavation and refilling	155,000 m^3	1.0 m height of excavation or refilling will be required over all line
Backfill with gravel	15,800 m^3	0.2 m thick for Mainte. road
Concrete volume for foundation	1,835 m^3	For conveyor head and tail stations, bridges, tunnels and buildings

11-2-2 Product Pipeline

Product methanol can be transported from the plant site via pipeline to Palembang shipping terminal, and by tanker thereafter to Java.

(1) System Description

1) Pipeline Route and Installation

The pipeline will be installed from Muara Enim where the on-site gasification complex will be constructed, to Pladju where the shipping facilities will be constructed, alongside the existing PERTAMINA pipeline and the existing main road as shown in Fig. 11-2-6 and Fig. 11-2-7.

It should be noticed that, in order to avoid the installation of the pipeline across the large Musi river, the shipping terminal is to be located on the right bank of the Musi river in the downstream part of the Ampera bridge which will restrict a tanker sailing up.

According to PERTAMINA Pramubulih and Muara Enim subprovincial offices, a pipeline should keep at least 16 meter distance between a main road, and land with 15 meter width must be purchased for a pipeline installation.

Two ways exist to install a pipeline, i.e. underground piping and aboveground piping. In this study, underground piping is selected from the viewpoint of security, to avoid the influence of temperature changes, as well as in accordance with the advice by PERTAMINA.

Pipeline should be laid one (1) meter below the ground and two (2) meters below the river bed, main road or railway where it crosses under government permission (Ref. 11-2-8).

ASTM grade B or equivalent is applied as material of pipe.

2) Pipeline Diameter

Pipeline diameter has been studied on the basis of the following.

i) Flow rate

No allowance is added to the quantity of normal flow rate equal to the normal methanol production capacity of 4,500 tons/day.

ii) Pipeline length

The distance from Muara Enim to Pladju alongside the existing PERTAMINA pipeline and main road is 180 km. However, since detouring is unavoidable in some area, total length has been set as 200 km.

iii) Elevation difference

The difference of elevation between Muara Enim and Pladju is to be 50 m.

iv) Fluid viscosity

The viscosity of methanol of 0.55 centi poise at 20°C of operating condition has been adopted.

Based on i) through iv) mentioned above, total pressure drop for SCH 40 piping has been calculated and shown in Table 11-2-2 which also indicates required boosting pump head as per the number of booster stations.

Table 11-2-2 Pressure Drop through Pipeline

Pipeline diameter (inch)	Total pressure drop (kg/cm^2)	Required Boosting Head (kg/cm^2G)		
		No. of Booster Stations		
		1	2	3
8	268.4	134.2	89.5	67.1
10	84.8	42.4	28.3	21.2
12	31.5	15.8	10.5	7.9

As a result of an overall evaluation of the installation cost and the operating cost of the pipeline, 12 inch size and SCH 40 thickness have been selected. As for the pipe thickness, 1 mm corrosion allowance is incorporated.

3) Booster Station

The number of booster stations should be decided as per the following.

i) Operation method

Attended operation system is adopted to regularly patrol the pipeline every day and check up operating conditions of the booster stations.

Daily patrol for the pipeline should be done by personnel in the booster stations as well as personnel in the shipping terminal and the tank yard in the plant. The range of patrol should be limited to maximum 50 km along the pipeline in order to enable patrol within daytime for each patrol team.

ii) Required pump head

Total pressure drop is shared by a delivery pump in the tank yard of the plant site and the pumps in booster stations. The required booster pump head depends on the number of booster stations and is shown in Table 11-2-2.

Considering i) and ii) mentioned above, booster pump stations are to be installed in two places.
In addition to daily patrol for the pipeline, annual inspection should be scheduled to measure pipeline thickness.
All of booster station pumps are to be driven by diesel engines.

4) Cathodic Protection System for Pipeline

Galvanic anode system and impressed current combined system is applied for the cathodic protection system for PE tape rapped pipeline. Galvanic anode is unable to apply to high acidity area where pH value is 3 to 4 due to the high self consumption rate of anode itself. Thus, impressed current system shall apply to this area instead of galvanic anode system. Approximately 20 km around Pladju is supposed as a high acidity area.
3,000 ohm-cm of soil resistivity is assumed for the design condition of anode groundbed design.
These soil resistivity data and pH value shall be measured and confirmed in the engineering stage.
Anode design life of 20 years is adopted.
Photovoltaic power (solar power) supply system shall be applied where AC power is not available.

(2) Major Equipment

Table 11-2-3 shows a list of major equipment.

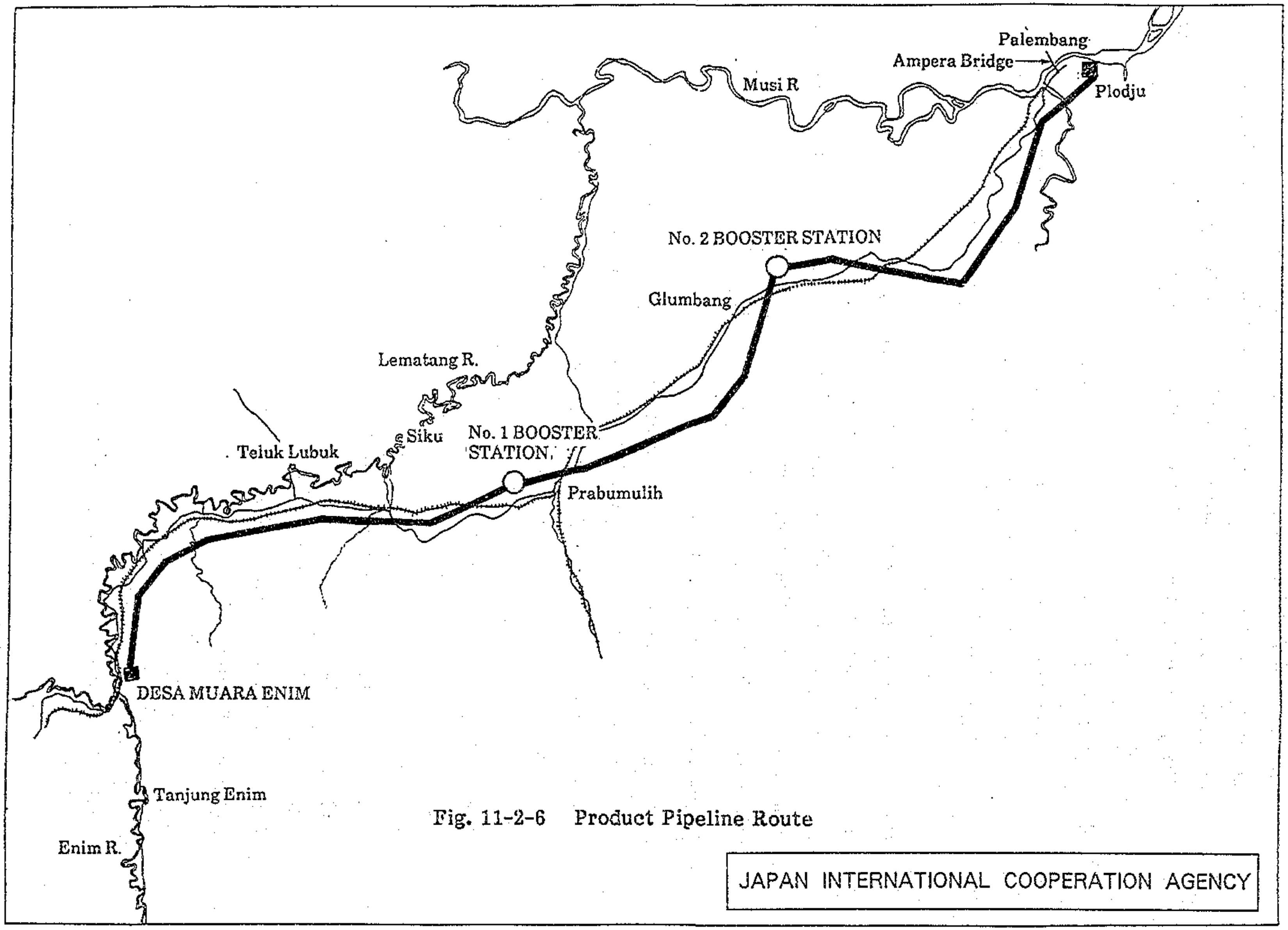

Fig. 11-2-6 Product Pipeline Route

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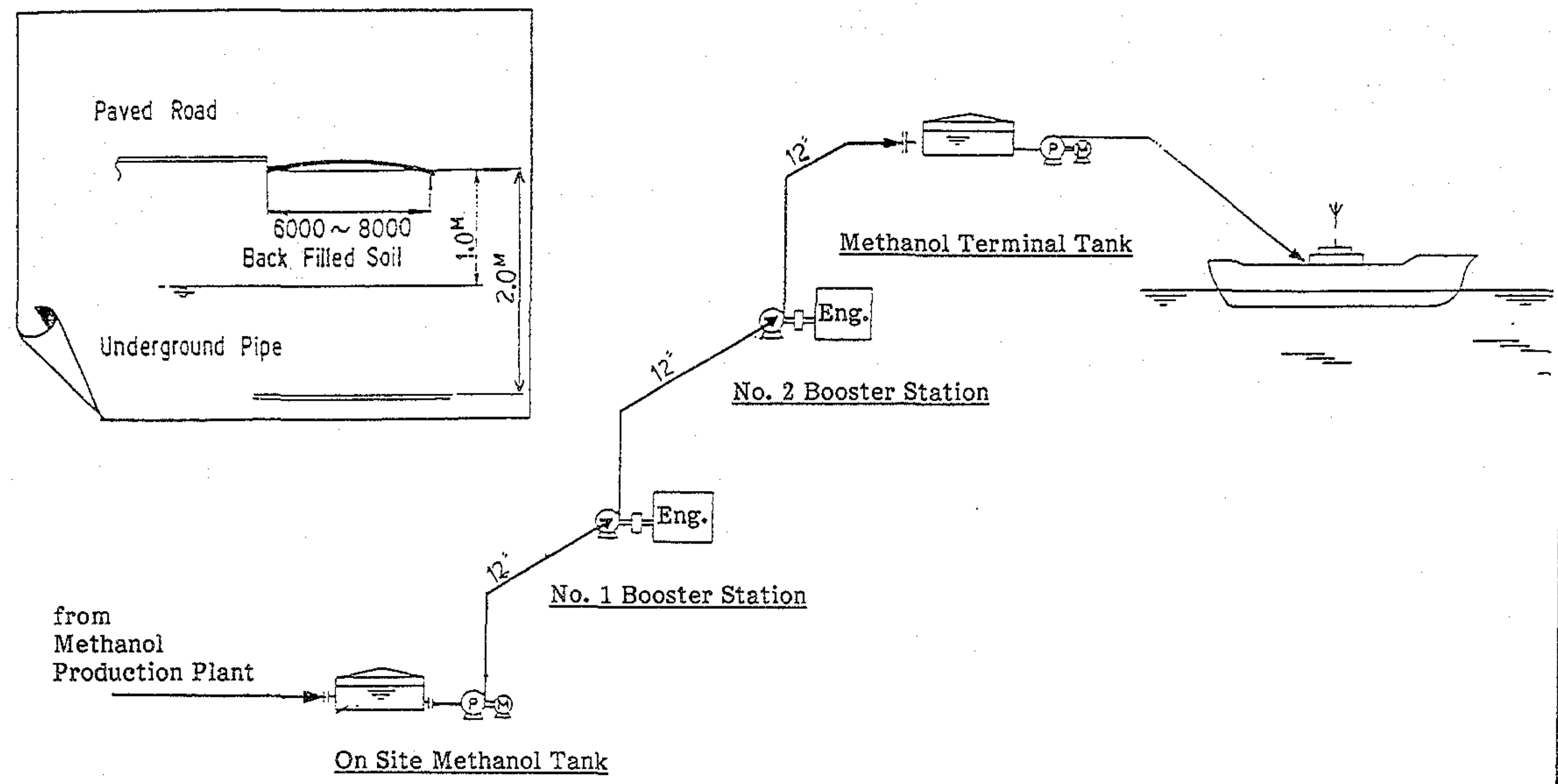

Fig. 11-2-7 Methanol Pipeline

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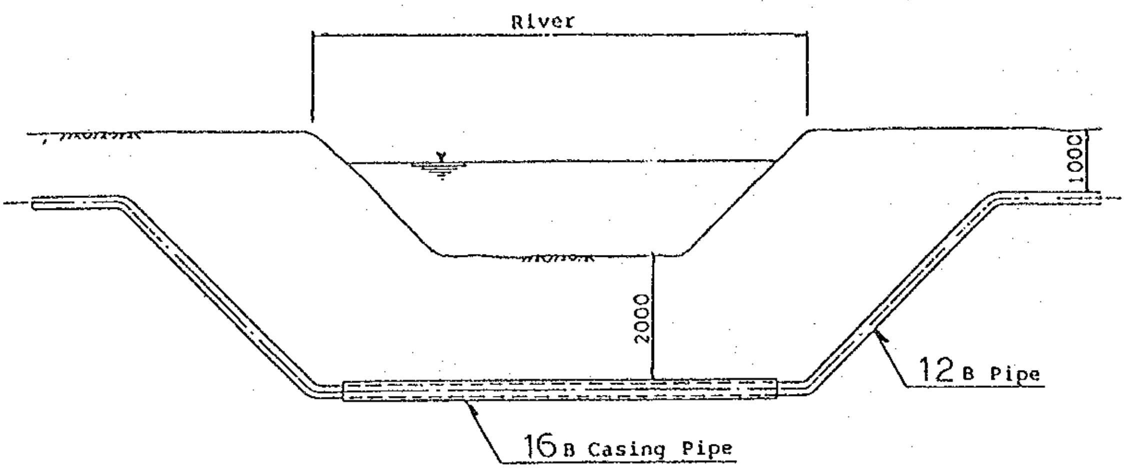
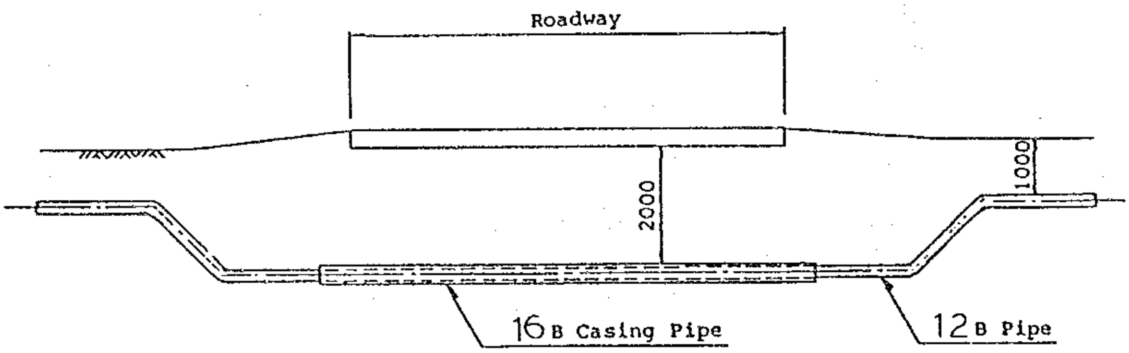
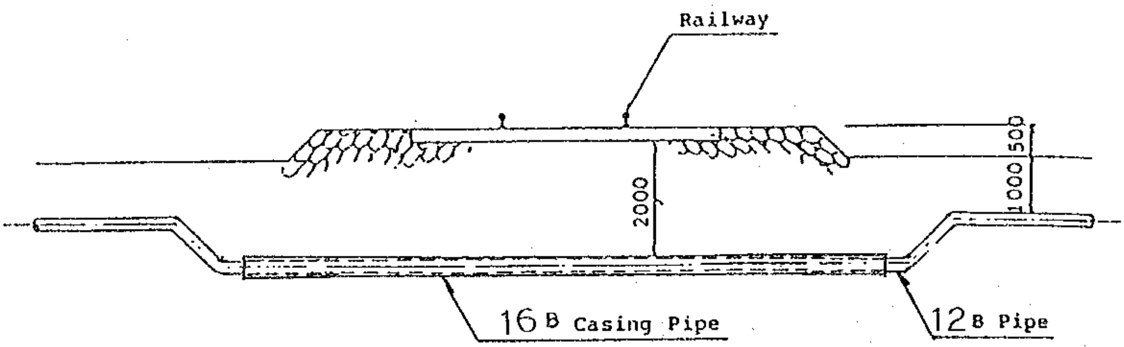


UNDER RIVER PIPE LAYING



UNDER ROADWAY PIPE LAYING



UNDER RAILWAY PIPE LAYING

Fig. 11-2-8 Under Ground Pipe Laying

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Table 11-2-3 Main Equipment List of Pipeline

Item No.	Service	Q'ty	Description	Material	Remarks
1	Pipe	200km	12 inch, 10.3 mm thickness Anticorrosion Method: Tape Rapping and Electricity	ASTM Grade B or equal	
2	Pump	4 sets/ B.S.	Diesel Engine driven 80 $m^3/h \cdot 13\ kg/cm^2$		B.S.: Booster Station
3	Methanol Surge Tank	2/B.S.	Cone-roof Type 100 kl	Carbon steel	
4	Fuel Oil Tank	2/B.S.	Cone-roof Type 30 kl	Ditto	
5	Diesel Engine	4/B.S.	75 HP		
6	Fire Fighting Facility	1 set/ B.S.			Based on NFPA
7	Cooling Water Facility	1 set/ B.S.			
8	Control Room	1 set/ B.S.			
9	Environmental Facility	1 set/ B.S.	Oil Separator		
10	Communication Facility	1 set/ B.S.			
11	Diesel Engine Generator	1/B.S.	300 KVA		Fuel methanol engines

11-2-3 Storage and Shipping Facilities

Methanol shipping terminal in Palembang consists of storage tanks and shipping facilities including tanker berth.
The total storage capacity of methanol tank at the plant site and the shipping terminal has been decided based on the study on security of supply of product.

(1) Security of Supply

In order to secure the supply of product methanol, the storage tanks should have sufficient capacity to cover the tanker capacity, unscheduled delay of arrival or departure of the tanker, expected annual maintenance of one train, and unexpected shutting down of the production plants and/or pipeline.

1) Tanker Capacity

Considering 4,500 tons/day methanol production capacity, shipping by a huge sized tanker is advantageous compared with shipping by small vessel, from economical point of view.
The maximum tanker capacity accessible to the Port of Palembang is 17,000 tons which corresponds to 3.7 days full production of the Methanol Plant assuming the load factor to be 98%.

$17{,}000 \text{ t} \times 0.98/4{,}500 \text{ t/day} = 3.70 \text{ days.}$

Covering the capacity of a tanker, the methanol tanks at the shipping terminal are to have storage capacity equivalent to a 3.7 day operation which is normally to be full of product.

2) Unscheduled Delay of Tanker

Unscheduled delay of tanker arrival or departure may be caused by weather condition or any other troubles.
Preparing for such unexpected delay which is assumed in this study to be 6 days, the methanol tanks at the shipping terminal are to have normally empty margin equivalent to the following.

a) During normal operation : 6 day full production of 3 trains

b) During annual maintenance of one train : 6 day full production of 2 trains = 4 day full production of 3 trains

3) Annual Maintenance

Annual maintenance of the production plants will be planned for one train by one train, so as to restrict the decrease in production capacity to a minimum. Annual maintenance of one train will take 30 days which corresponds to 10 day full production of three trains.

1,500 t/day × 30 day/4,500 t/day = 10 days

Preparing for the annual maintenance of one train mentioned above, the storage tanks in the shipping terminal and the plant site are to have storage capacity in a state of normally full stocks which cover 10 day full production.

4) Unexpected Shutdown of Production Plants

Following considerations are reflected in the design in order to keep a high operation factor of the Coal Gasification Complex.

a) 4 hour daily maintenance is planned for the Belt Conveyor System. With an enough conveyor capacity and a coal bunker at the plant site covering 8 hours, stable supply of coal can be attained.

b) The Gasification Plant consists of 6 trains, 4 out of which is normally in operation, one is under maintenance and one is stand-by.

c) Utility pumps are provided with stand-by spares.

d) For large-sized compressors and turbine which are not provided with stand-by spares, 100% spare parts are stored in the warehouse.

However, unexpected shutdown of the plants should be incorporated in the study on storage capacity as follows.

a) One day shutdown of one train is caused by the trouble with instrumentation system, electricity system or support equipment, etc. Production loss with this trouble is equivalent to 0.3 day full production 1,500 t/day × 1 day/4,500 t/day = 0.3 days.

b) Trouble with large sized compressor and turbines occur once per 10 years resulting in 6 day shut down of one train which corresponds to 2 day full production.

$1{,}500$ t/day × 6 day/$4{,}500$ t/day = 2 days

Since the probability that more than two accidents happen at the same time is very little, the case of a single problem should be considered. As a result, the methanol tanks are to have capacity to cover 2 day full production.

5) Unexpected Shutdown of Pipeline

In order to keep high operation factor of the pipeline as well as the production plants, considerations are incorporated into the design.

a) Delivery pumps at tank yard and booster stations are provided with stand-by spares.

b) Sufficient corrosion prevention system is applied to the pipeline design.

Same as the production plants, however, unexpected shutdown of the pipeline should be taken into account.

a) Small trouble with the pipeline happens once a year which is repaired in one day.

b) Big trouble with the pipeline occurs once per 10 years causing 3 day shutdown of the pipeline for insulation, liquid removal, repair, inspection and restart.

Countermeasures against 3 day shutdown of the pipeline should be reflected in the study of storage capacity. Different from troubles with the production plants, two kinds of storage margin are to be considered.

a) Empty margin at the plant site for receiving product from the plants which are still in operation.

b) Margin at the shipping terminal in stock of product methanol.

Each margin is to be equivalent to 3 day full production during normal operation and 2 day full production of 3 trains during annual maintenance of one train.

6) Quality Inspection

In addition to the factors mentioned above, it should be noted that one tank in the plant site is normally full waiting for quality inspection. After a tank is filled, it will take around one day for product sampling, quality analysis at the laboratory, and certification before delivery. Consequently, storage capacity should cover one tank (equivalent to X day full operation) + one day (0.7 day during annual maintenance) full production of 3 trains.

Factors determining the minimum storage capacity of methanol tanks are summarized in Table 11-2-4 and 11-2-5.

Storage Capacity during Normal Operation

As shown in Table 11-2-4, the total storage capacity should cover 16.7 + X day full production. Considering that realistic value for X is 2 or 3, the capacity is allocated as follows.

Terminal	:	12.7 days
Plant	:	6 - 7 days
Total	:	18.7 - 19.7 days

Storage Capacity during Annual Maintenance

As shown in Table 11-2-5, the total storage capacity required is 19.7 day full production which is allocated by the same treatment as in the case of 1) as follows.

Terminal	:	14 - 15 days
Plant	:	5.7 - 4.7 days
Total	:	19.7 days

Based on the above, allocation of storage tanks with 135,000 kℓ total capacity has been planned as follows which corresponds to 24 day full production of 3 trains.

Shipping Terminal	:	90,000 kℓ (22,500 kℓ × 4)	(16 days)
Plant Site	:	45,000 kℓ (15,000 kℓ × 3)	(8 days)
Total	:	135,000 kℓ (108,000 tons)	(24 days)

Table 11-2-4 Minimum Storage Capacity of Methanol Tanks (Normal Operation)

Item	State	Location*1)	Capaicty*2)
(1) Tanker capacity	Full	T	3.7
(2) Tanker delay	Empty	T	6.0
(3) Unexpected shutdown of one train	Full	T or P	(2.0)*3)
(4) Unexpected shutdown of pipeline	Full	T	3.0
(5) Ditto	Empty	P	3.0
(6) Quality inspection	Full	P	X+1.0
Subtotal		T P	12.7 4.0+X
Total		T and P	16.7+X

Note *1) T : The shipping terminal
P : The plant site

*2) The capacity represents the number of days in full production of 3 trains.

*3) Since it is not necessary to consider that unexpected shutdown of one train and pipeline occurs simultaneously, this can be covered by item (4).

Table 11-2-5 Minimum Storage Capacity of Methanol Tanks
(Annual Maintenance of One Train)

Item	State	Location*1)	Capaicty*2)
(1) Tanker capacity	Full	T	3.7
(2) Tanker delay	Empty	T	4.0
(3) Annual maintenance	Full	T or P	10.0*3
(4) Unexpected shutdown of one train	Full	T or P	(2.0)*4
(5) Unexpected shutdown of pipeline	Full	T	(2.0)*4
(6) Ditto	Empty	P	2.0
(7) Quality inspection	Full	P	X+0.7
Subtotal		T P	17.0-X 2.7+X
Total		T and P	19.7

Note *1) Same as Table 11-2-4

*2) Ditto

*3) This can include item (7)

*4) Item (4) and (5) can be covered by item (3) (or (7)).

(2) System Description

The following preconditions have been set up in making basic plans for the methanol storage and shipping facilities.

1) Location

As stated in Section 11-2-2, it is proposed that the methanol shipping terminal be constructed in the area near the PERTAMINA Refinery in Pladju which is on the right bank of the Musi river in the downstream area of the Ampera bridge.

2) Size of Inbound Tankers

On the basis of the size of the largest tanker that has ever anchored at the pier of Palembang in the past, size of a tanker is to be 17,000 dead weight ton (DWT).
As an alternative method, two (2) 2,000 ton class small vessels are available simultaneously.

3) Means of Shipping Methanol

Methanol will be shipped from methanol tanks by means of loading arms which are provided on the sea berth of dolphin type.

4) Methanol Tank

Four methanol storage tanks are to be installed at the shipping terminal.
The capacity of a methanol tank is 22,500 kℓ with margin, so that it can store methanol for a 17,000 DWT tanker or two 2,000 DWT vessels.
The tank is of dome roof type which is commonly adopted for a large capacity tank.

5) Quantity of Methanol to be Handled Annually

$$4{,}500 \text{ t/day} \times 333 \text{ days/year} = 1{,}500{,}000 \text{ tons/year} = 1{,}880{,}000 \text{ k}\ell\text{/year}$$

6) Number of Days Occupied by a Tanker

Three days

7) Number of Inbound Tankers a Year

About 88 tankers per year.

8) Electric Power Supply

Diesel generators will be provided for power supply to the terminal facilities. Commercial electricity will be purchased for illumination of offices, etc.

9) Security and Fire Fighting Facilities

Foam fire fighting facility, fire dike and fire extinguisher will be installed in accordance with the NFPA standards.

10) Environmental Protection Facility

An API oil separator will be installed as waste water treatment facility.

Fig. 11-2-9 shows the process flow diagram of the Methanol Shipping Terminal.

(3) Major Equipment

Table 11-2-6 shows a list of major equipment for the Methanol Shipping Terminal.
Fig. 11-2-10 shows the plot plan of the shipping terminal.
Tank foundation and the shipping berth are shown in Fig. 11-2-11 and Fig. 11-2-12 respectively.
The pier is designed in a dolphin type with total length of 230 m.

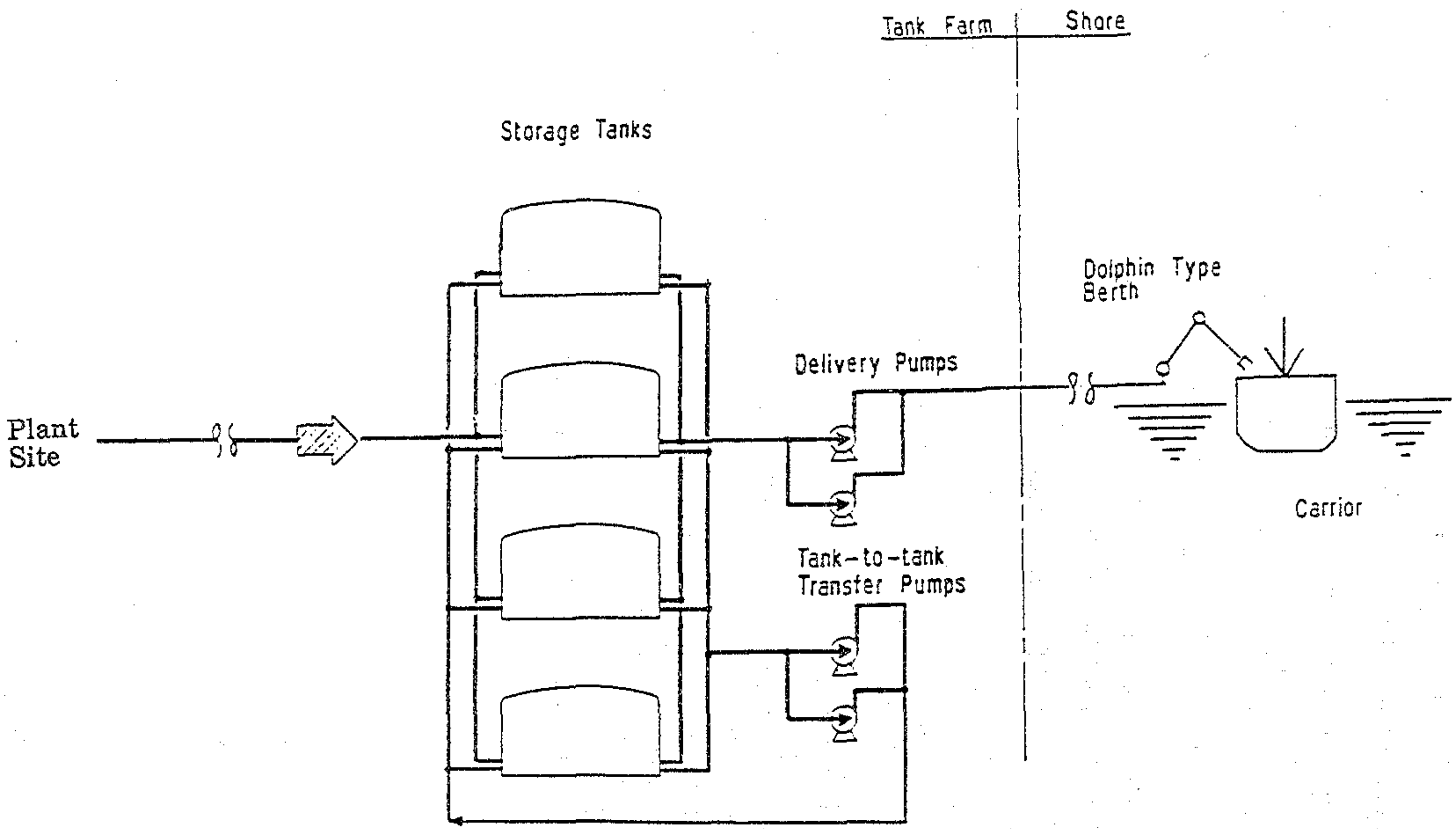

Fig. 11-2-9 Flow Diagram of Methanol Shipping Terminal

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Table 11-2-6 Main Equipment List of Terminal

Item No.	Service	Q'ty	Description	Material	Remarks
1	Methanol Storage Tank	4	Dome roof Type 22,500 kl	Carbon Steel	
2	Fuel Storage Tank	1	Cone-roof Type 180 kl	Ditto	
3	Water Tank	2	Cone-roof Type 10,000 kl	Ditto	
4	Methanol Delivery Pumps	2	Diesel Engine Driven 175 m^3/h kg/cm^2G		
5	Tank-to-tank Transfer Pump	2	Centrifugal Type 175 m3/h 30 mH		
6	Water Pump	2	Diesel Engine Driven 17 $m^3/min.$ 10 kg/cm^2G		
7	Drain Pump	2	Centrifugal Type 8 $m^3/min.$ 30 mH		
8	Diesel Engine Generator	2	650 KVA		
9	Oil Separator	1	API Type		

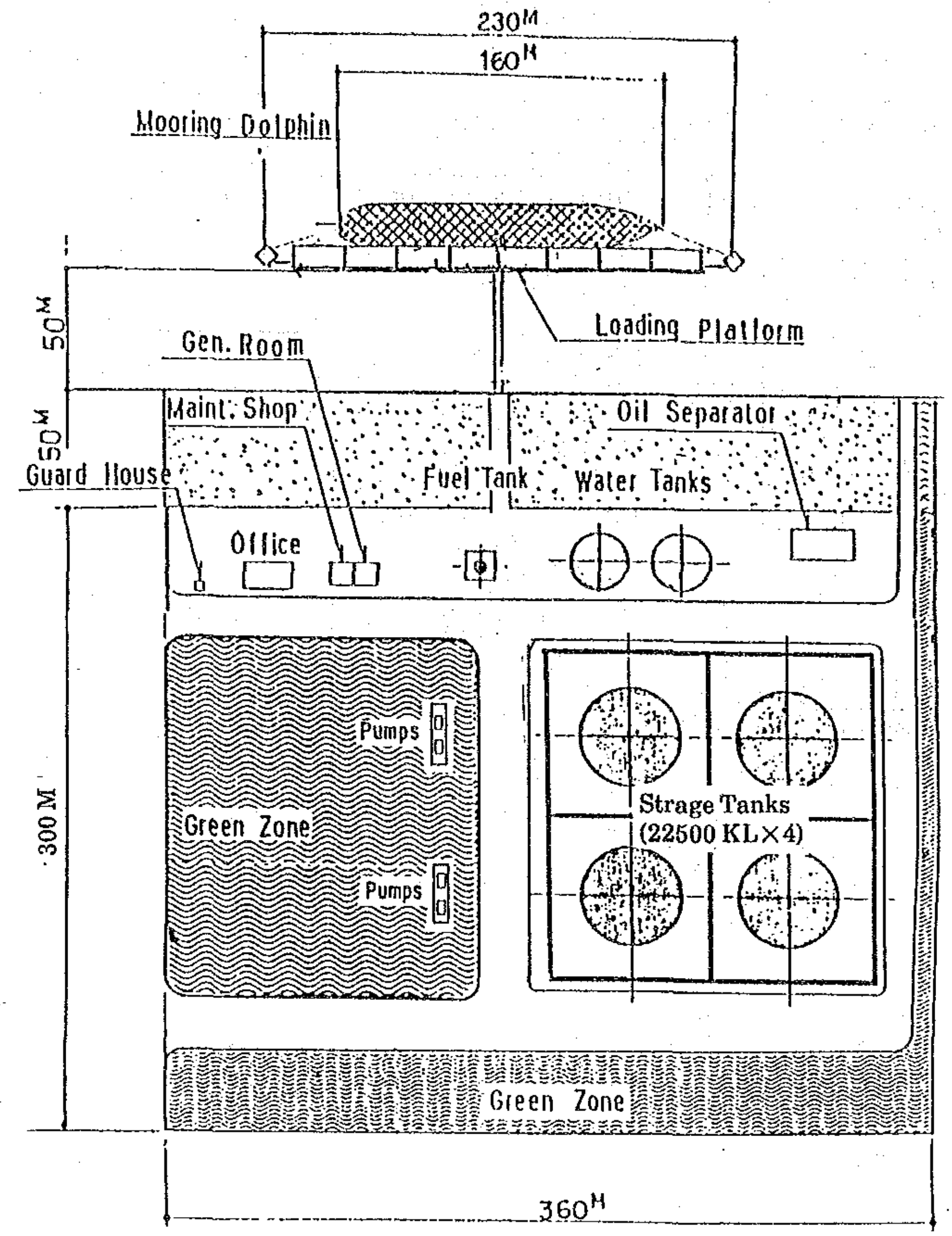

Fig. 11-2-10 Shipping Terminal Plot Plan

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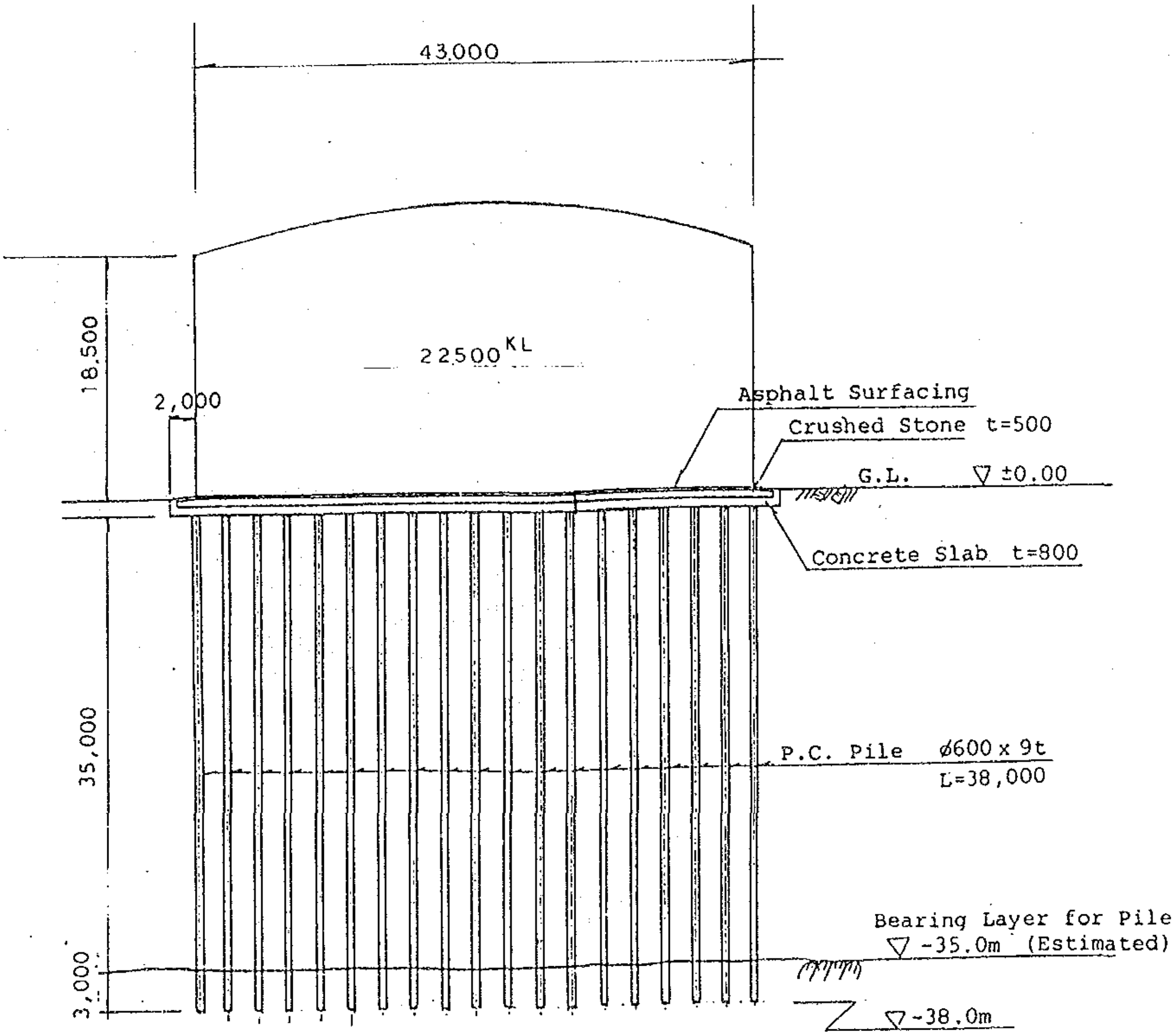

Fig. 11-2-11 Methanol Tank Foundation

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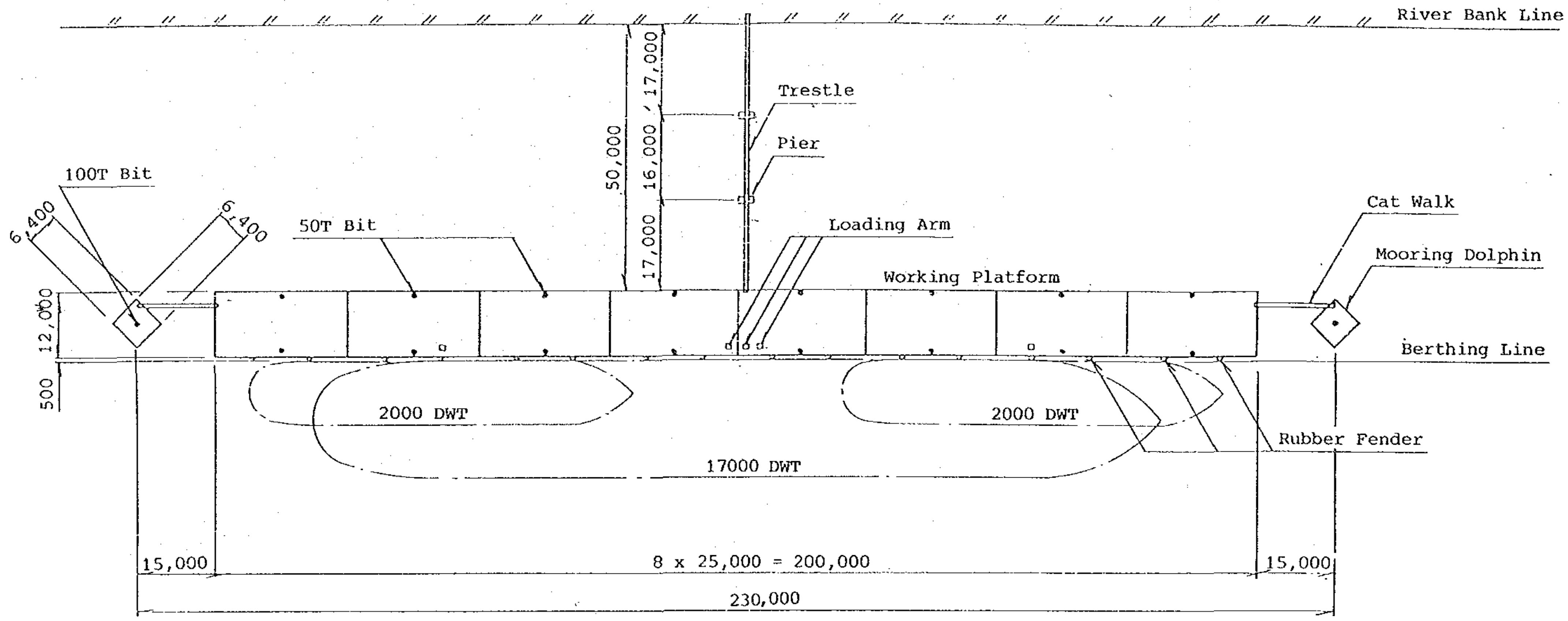
METHANOL TANK FOUNDATION

PLAN S = 1/1000



FRONT VIEW S = 1/1000

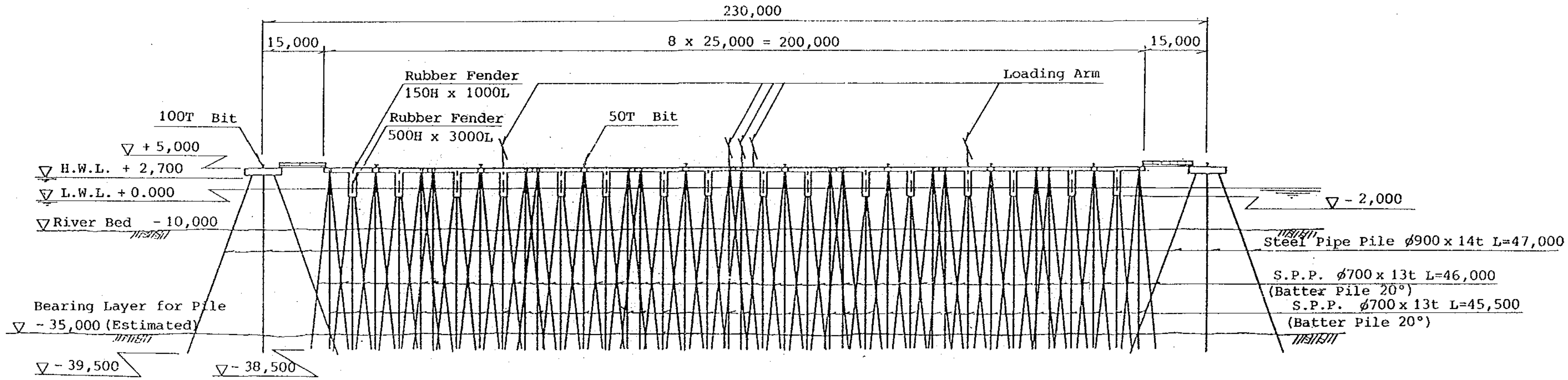


Fig. 11-2-12 Methanol Shipping Berth

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METHANOL SHIPPING BERTH

11-2-4 Water Intake Facility

(1) System

Fig. 11-2-13 shows the Water Intake System flow.

A water pool is prepared close by the river at lower level than the surface of river water so that the water can flow into the pool spontaneously.

While the raw water is sent from the pool to a precipitator, coagulant is addeded to separate suspended mud as coagulated - sedimented flocculation.

Supernatant water is pumped up from the precipitator and is sent to the plant site as industrial water.

After settled, flocculation is discharged by a drainage pump to a pond to be located nearby, where residual water is naturally vaporized.

(2) Basic Design Data

1) Capacity : 3,475 t/h

2) No. of Equipment

i) Water Intake Pool : One

ii) Coagulation Sedimentation Unit : One

iii) Water Pit : One

iv) Number of Water Sending Pump : Nine
(Three units are to be installed at each phase)

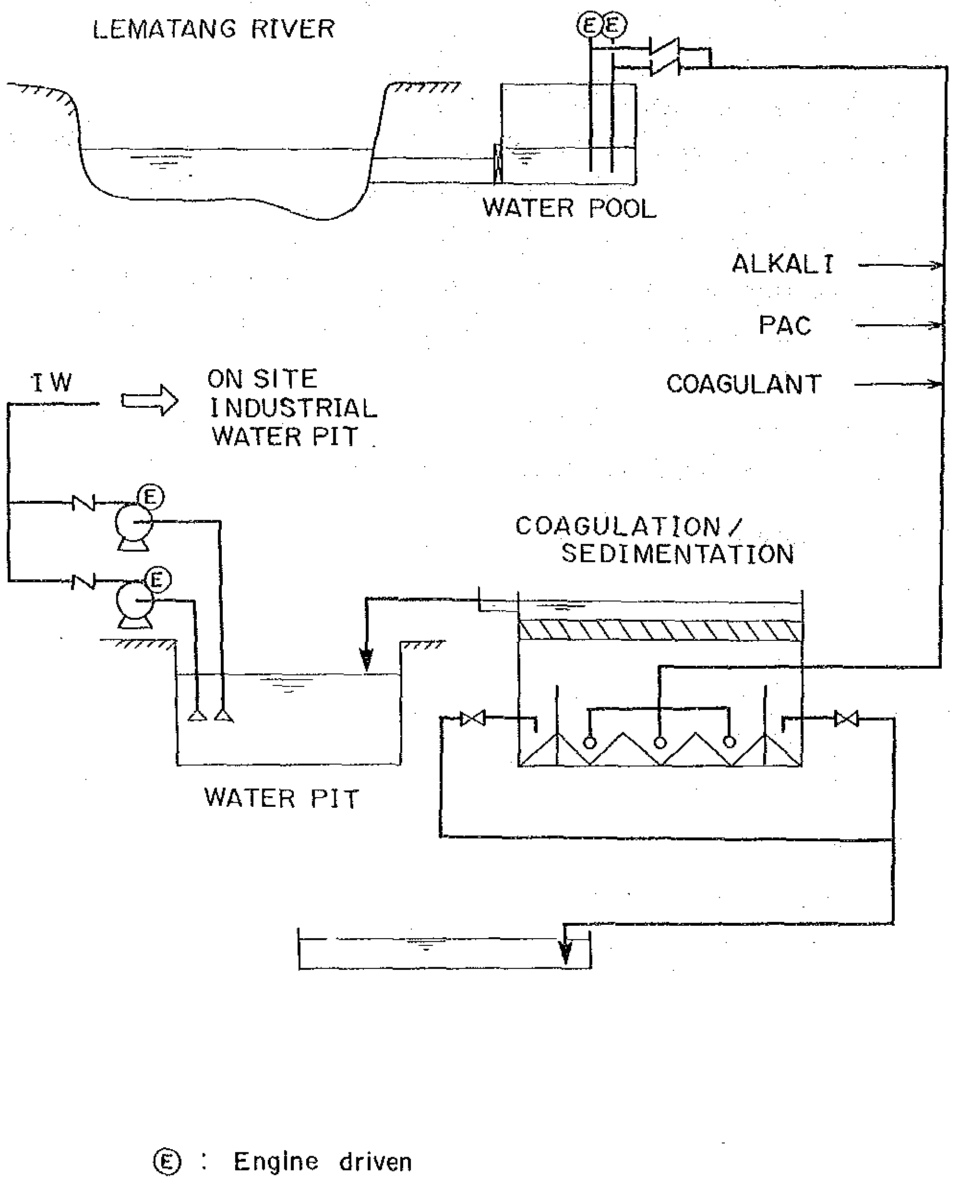

Fig. 11-2-13 Water Intake System

11-2-5 Waste Water Disposal

As stated in Section 11-1-7, waste water from each plant is treated at the on-site, led into a pond for the prevention of accidental discharge of methanol, and sent to the riverside for discharge after confirmation of the water quality within the discharge standard.
Since the discharge standard satisfies the environment standard to be studied in Section 12-3, the treated waste water can be discharged into the Lematang river.

11-2-6 Solid Waste Disposal

Major solid wastes to be finally treated at the off-site are slag from gasifiers, dust from dedusters in the Coal Gasification Plant and ash from the Boiler Plant. They are gathered in the solid waste handling area, transferred to the soil dump area in the mining site by dump trucks and discarded into an abondoned mine. The treatment mentioned above is applicable because they are harmless as indicated by the following component data.

1) Slag	CaO	40 %	
	SiO_2	27 %	
	Al_2O_3	22 %	
	FeO	5 %	
	Others	6 %	(MgO, MnO, etc.)
2) Dust	T. Fe	25 %	
	T.C	40 %	
	SiO_2	16 %	
	Al_2O_3	15 %	
	Others	4%	(CaO, MgO, etc.)
3) Ash	$CaSO_4$	40 %	
	C	6 %	
	SiO_2	20 %	
	CaO	10 %	

Al_2O_3 19 %

Others 5 % (Fe_2O_3, MgO, etc.)

The amount of each sold waste is as follows:

Slag	:	11 t/h
Dust	:	10 t/h
Ash	:	9.9 t/h

11-2-7 Resident Area

In order to accommodate people working for the coal gasification complex, a resident area will be constructed consisting of the following.

1) Company house : 400 units for married employees
2) Dormitory : 3 units for 300 unmarried employees
3) Mosque and church : 1 each
4) Shopping Center : 2
5) Sport and Recreation Facilities
    i) Football Field : 1
    ii) Gymnasium : 1
    iii) Tennis Courts : 2
    iv) Swimming Pool : 1
6) Clinic : 1
7) School
8) Bank and post office
9) Park

12. ENVIRONMENT AND SAFETY ASSESSMENT

12-1 GENERAL

12-1-1 Execution of Environment Assessment

Environment and Safety Assessment for this Project have been executed by the updated Project data and predictions method in Japan as mentioned below. Furthermore before the construction stage, Environment and Safety Assessment shall be reconfirmed at points of environmental conditions on site, town planning of Muara Enim, and another environmental component factors such as natural environment.

1) Grasp of Activities which Affect Environment

   Project activities which may affect environment by its execution will be grasped considering project contents and environmental characteristics of the related area.

2) Grasp of the Present State of the Environment and the Selection of the Items of Prediction and Evaluation

   From the items relating to human health and the living environment, items of study, prediction, and evaluation (environment factors) will be selected.

3) Study and Setting up of the Object of Environmental Conservation (the Level of Environmental Conservation)

   With respect to environment items, the object of environmental conservation will be set up quantitatively on the basis of restricted value in Japan.

4) Prediction of Environmental Impact

   Environmental impact from the operation of facilities will be predicted.

5) Study on Environmental Conservation Measure

   Environment conservation measures will be studied on the basis of technical point to minimize impact on the environment from the experiences and knowledge obtained from the environment assessment.

6) Environment Assessment

Environment assessment will be conducted by studying on adaptability of the object of environment conservation.

Fig. 12-1-1 shows execution procedures of Environment Assessment.

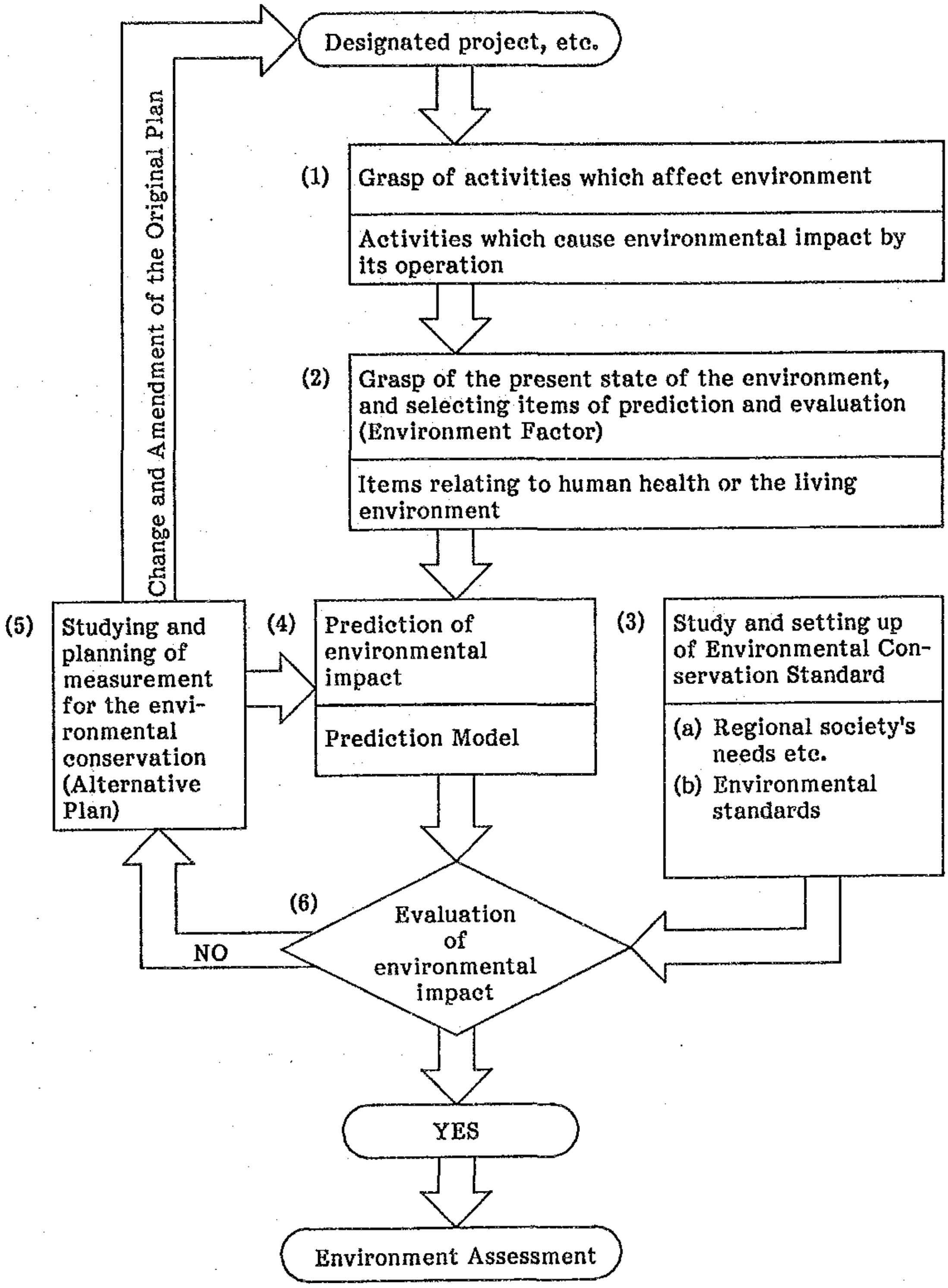

Fig. 12-1-1 Execution of Environment Assessment