4.2 Limestone

4.2.1 Present Conditions in Bulgaria

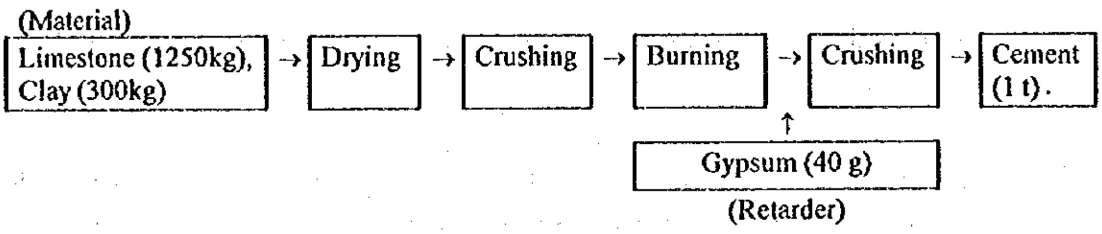
(1) Distribution of limestone resources

The limestone resources are distributed within 100km off Sofia, capital city and additionally other resources are distributed around the Black Sea and in the south area of this country. Figure 4-2-1 shows the limestone resource distribution and cement factories.

(2) Cement industry

(a) Limestone is main material for cement production.

The production method (example: production of cement of 1 ton) is approximately as follows.



(b) Current cement factories exist near limestone resources and there are 6 factories in this country. Meanwhile, most of clay can be procured near the factories. As for fuel, all the cement factories import natural gas from Russia to fill all requirement for the fuel.

(c) Cement production amount stayed around 5 million tons until 1990, but it dropped to less than half of it after 1991 when Bulgaria economy changed to market economy system. The prominent reason is that Bulgarian economy was sluggish and encountered inflation due to competition of its various industries with those of other countries and conventional construction method using much cement has not been used so frequently. Most of cement produced is consumed domestically and only a slight amount of it is exported.

(d) Table 4-2-1 shows production capacity of each cement factory.

The quality of produced cement complies with the ISO standard. Because no separator is installed on finishing with it is impossible to produce high quality cement except for only Vulkan factory.

(e) At present, on the environmental-protection front, attention is being focused on soot and dust alone. With this being the situation, although the individual plants are equipped with electrostatic precipitators in front of their stacks, they stand in need of satisfying the EC standard (of 80 mg/m^3N) from 1995 onward. As for noise and vibration, they are not posing any particular problem because of the low numbers of dwellings in the neighborhood of the concrete plants.

4.2.2 Characteristics of Mines near Power Plants

Limestone mines located near Maritsa East No. 1 thermal power plant and their major characteristics are as follows.
Figure 4-2-2 shows the location of each mine.

(1) Bratyakunchevi Mine (about 80km north of the power plant, about 25km east of Stara Zagora)

(a) This limestone mine is managed by Inermat Company whose headquarter is located in Stara Zagora.

(b) The plan to construct a cement plant at this mine has been aborted in its tracks due to the fact that the Dimitrovgrad mine (Vulkan Plant) was developed earlier. Currently, unfinished facilities are being operated to produce ballast/gravel (with a yearly production of 1 million tons) to be used for roads as well as to be used for construction materials. Railroad facilities are available all the way to the power plant.

(c) The location of limestone deposits is about 7 km into the mountains from the stone-crushing facilities. The estimated reserves of limestone are some 90 x 10^8 tons. Below the surface layer of clay measuring 2 to 3 meters in thickness, a 4-to-5-meter thick seam of limestone lies.

(2) 2 sites of dimitrovgrad mine (Yurdere, Chala)

(Both about 60 ~ 90km south west of the power plant, about 10km north of and about 20km south east of Haskovo)

(a) This mine managed by Vulkan Cement Company (Dimitrovgrad).

(b) The cement factory started production in 1947 and limestone to be used for cement production is collected at 2 sites. The current consumption is 500 x 10^3 ton/year and the production is estimated to be able to continue until 2050.

(c) The reserve of limestone is as follows.

- Yurdere mine : 214×10^6 ton
- Chala mine : 33×10^6 ton

(d) The method of transportation from the limestone mine to the cement factory is as follows.

Yurdere mine	——→ 7 km Truck (15t)	Crushing (*)	——→ 2.5 km Ropeway	Cement factory

* Crushed to less than 25m/m in diameter.

Crusher (capable of crushing to less than 1m/m): 400 t/h x 1, 250 t/h x 1 (for spare)

(3) Kamenets mine (about 100km north east of the power plant, about 30km away from Jambol)

(a) This mine is possessed by Jambol.

(b) As no geological survey has been conducted, data about the reserve are unknown.

4.2.3 Quarry and Transportation Plan

(1) Quarry plan

(a) Study parameters

1) Quarry: 4 quarry mines (Bratyakunchevi, Yurdre, Chala, Kamenets)

2) Reserves: Bratyakunchevi = 90×10^6 ton (not developed)
   Yurdere = 214×10^6 ton (in use for cement)
   Chala = 33×10^6 ton (in use for cement)
   Kamenets = - (not surveyed)

3) 500×10^3 ton/year of limestone produced in Yurdere and Chala mines was consumed as raw material for cement and their mining operations will continue until 2050.

4) The quarry time is 10 hours per day on average because of daylight time, labor safety, etc.

5) Amount of limestone necessary for a replacing plant:
   180 t/h (90 t/h x 2 units)
   4,300 t/d (≒ 180 t/h x 24 hr)
   1,100,00 t/y (2 units, annual utilization factor: 0.7)

6) Table 4-2-2 shows the properties of limestones of each mine.

7) The limestone grain size shall be less than 50 m/m ϕ considering convenience at the time of transportation and storage.

(b) Study result

1) Yurdere mine is the most recommendable due to its reserve and property of limestone, but there are problems to be resolved in relation with cement industry. On the other hand, because there is no important problem in limestone (dolomite) collected at Bratyakunchevi mine for combustion test of lignite, in terms of combustion and desulfurization, this limestone can be crushed to required diameter and transported by railway and this mine can be developed as a mine specialized for desulfurizing agent. Therefore, the required crushed stone should be collected from Bratyakunchevi mine.

2) According to the amount of limestone required per day, 430 ton will be collected every hour.
[Q = (4,300 t/d) ÷ (10 hr) = 430 t/h]

3) To crush limestone to required diameter, existing crushers will be used.
Limestone shall be transported from the collection site to crusher by means of ropeway (to be newly established over 7km).

(2) Transportation plan

(a) Study parameters

1) Transportation method : Railway (Bratyakunchevi mine to power plant)
2) Distance up to the power plant : Approximately 80km
3) Amount of transported limestone : 4,300 t/d (430 t/h × 10 hr)

(b) Study result

1) 8-trains are necessary per day. [8 ≒ (4,300) ÷ (55) ÷ (10)]
2) Assuming that limestone loading time for a train (10 freights) is 40 minutes (including train come-in/out), the operation time of the train is 6 hours per day.
[6 ≒ (8) x (40) ÷ (60)]

4.2.4 Items to be studied for project implementation

(1) With limestone intended for use as the desulfurization agent (measuring approximately 3 mm across or smaller), the transportation of finely crushed limestone, which has been ground in-situ at the mine, is considered to give rise to pollution problems due to the

structure of freight cars. It may, therefore, be desired that limestone be pulverized to the ultimate grain size at the power plant.

(2) As Bratyakunchevi mine has not been developed and its geological survey was conducted as before as 30 years ago, it is recommended to survey its geological feature again.

Development of limestone mine must be conducted in cooperation with flue gas desulfurizer installation plan of Maritsa East No. 2 thermal power plant (No.8 unit). Additionally, the development of the mine needs construction cost and operation cost (for every year) mentioned below.

[Construction cost]

(a) Drilling equipment: a set 4,000,000 US$

Cost necessary for purchase and installation of all equipment for drilling of stones by drilling equipment, collection of the stones by bulldozers and transportation to a ropeway station by tracks.

(b) Transportation equipment: a set 10,000,000 US$

Cost necessary for purchase and installation of transportation equipment from the stone collection site to the loading place. However, the cost may change drastically depending on geographical condition, etc.

[Operation cost] a set 800,000 US$/year

Cost relating to utilities (fuel, lubricant, electricity, etc.), transportation by railway, etc.

(3) To exploit the Yurdere mine, there is a necessity of having prior consultation with Vulkan Cement Company and responsible Government agencies regarding such issues as transportation methods and cement production. It is desired that a renewed geological survey be conducted in order to obtain accurate geological information/data including possible reserves. Considering the distance to the power plant, safety concerns, and the required transportation capability, there is a necessity of developing a railroad route and building railroad tracks.

Table 4-1-1 Coal Mines in Bulgaria

MINES \ DATA	Balance of Deposits on 01.01.1994 thousand t.	Type of Coal	Mining method
1. Maritsa East Mines	2,312,214	Lignite	Opencast
Of them : Troyanovo 1	684,677	Lignite	Opencast
Troyanovo North	512,855	Lignite	Opencast
Troyanovo 3	512,855	Lignite	Opencast
2. Beli Breg Mine	26,257	Lignite	Opencast
3. Staniantsi Mine	18,027	Lignite	Opencast
4. Chukurovo Mine	10,659	Lignite	Opencast
5. Bistritsa Mine	31,588	Lignite	Underground
6. Maritsa Basin Mines	61,753	Lignite	Underground
7. Bobov Dol Mines	165,985	Brown	Underground and opencast
8. Pernik Mines	25,783	Brown	Underground and opencast
9. Cherno More Mine	20,709	Brown	Underground
10. Pirin Mine	20,189 } 24,369	Brown	Underground
	4,180	Lignite	Underground and opencast
11. Balkan Basin Mines	7,253	Hard	Underground
12. Anthracite Mine	3,746	Anthracite	Underground

Table 4-1-2 Coal Produced during the Period 1.1.1992 - 31.10.1994 and Utilization Break - down

10^3 tonnes

Company	1992				1993				January - October 1994			
	Tonnage Estimate Total :	Steam Coal	Briquet-table Coal	Commodity Fund & Other Consumers	Tonnage Estimate Total :	Steam Coal	Briquet-Table Coal	Commodity Fund & Other Consumers	Tonnage Estimate Total :	Steam Coal	Briquet-table Coal	Commodity Fund & Other Consumers
1	2	3	4	5	6	7	8	9	10	11	12	13
1. Maritsa East Mines												
Of them : Troyanovo 1	7,672	5,059	2,613		7,538	4,364	3,174		5,272	3,075	2,197	
Troyanovo North	8,406	7,271	1,135		8,010	7,454	556		6,726	6,562	164	
Troyanovo 3	8,042	8,042			7,209	7,209			6,033	6,033		
2. Beli Breg Mine	563	534		29	505	480		25	410	386		24
3. Staniantsi Mine	584	542		42	535	495		40	448	415		33
4. Chukurovo Mine	430	367		63	452	389		63	325	282		43
5. Bistritsa Mine	80	51		29	85	61		24	42	38		4
6. Maritsa Basin Mines	863	863			926	926			755	755		
7. Bobov Dol Mines	1,426	1,275		151	1,483	1,334		149	1,118	1,012		106
8. Pernik Mines	1,314	1,169		145	1,389	1,240		149	1,080	966		114
9. Cherno More Mine	240	235		5	212	204		8	164	160		4
10. Pirin Mine	402	303		99	364	269		95	247	199		48
11. Balkan Basin Mines	201	201			222	222			126	126		
12. Anthracite Mine	45			45	41			41	25			25

Table 4-1-3 Coal Mining Forecast in Bulgaria

10^3 tonnes

Company	1995		1996		1997		1998		1999		2000		2001 - 2005		2006 - 2010		2011 - 2015		2016 - 2020	
	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal	Estim. Q-ty	Steam Coal
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Maritsa East Mines																				
- As per Coal Mining Development Concept	22,254	18,334	25,890	23,090	26,430	23,630	27,380	24,580	27,880	25,080	28,380	25,580	32,000	29,000	32,000	29,000	32,000	29,000	32,000	29,000
- As per the Maximum Mining Capacities	29,500	25,000	31,000	27,150	33,000	29,300	33,500	30,200	34,000	30,700	36,500	30,800	39,500	36,900	39,500	36,900	39,000	37,000	31,400	29,400
2. Beli Breg Mine	522	450	530	450	570	450	665	565	665	565	665	565	665	565	665	565	665	565	665	565
3. Staniantsi Mine	540	500	540	500	540	500	710	610	710	610	710	610	900	800	900	800	900	800	173	100
4. Chukurovo Mine	440	350	440	360	450	360	450	360	450	360	450	360	450	360	450	360	450	360		
5. Bistritsa Mine	2,000	1,370	1,830	1,540	1,830	1,590	1,910	1,660	1,910	1,660	1,910	1,660	1,845	1,660	1,810	1,660	1,865	1,660	1,890	1,660
6. Maritsa Basin Mines	1,950	1,110	1,190	1,010	1,252	1,100	1,216	1,075	1,200	1,060	1,200	1,075	1,085	1,000	940	920	970	920	915	865
7. Bobov Dol Mines	1,000	995	995	990	995	990	995	990	995	990	995	990	995	990	995	990	995	990	995	990
8. Pernik Mines	205	160	215	160	215	180	215	180	215	180	215	180	235	180	235	180	235	180	235	180
9. Cherno More Mine	330	255	365	225	385	245	395	255	415	275	415	275	445	305	365	225	365	225	365	225
10. Pirin Mine	220	210	237	200	237	170	355	170	475	290	475	290	495	300	495	300	495	300	495	300
11. Balkan Basin Mines	110	80	110	65	110	65	110	65	110	65	110	65	110	65	110	65	110	65	110	65
12. Anthracite Mine	24		28		28		28		28											

Table 4-1-4 SPECIFICATION
of MARITSA EAST LIGNITE BASIN / TROYANOVO 2 / AFTER 1998
for MARITSA EAST 1 TPP

No.	Indicator	Measure Unit	Coal Analysis N1 Guaranteed	N2 with Amax	N with Wmax	N with Qmax
1.	Ash, air-dried base	%	35.50	45.00	33.00	30.0
2.	Moisture as received	%	55.0	49.0	57.0	55.0
3.	Ash as received	%	15.98	22.95	14.09	13.5
4.	Carbon as received	%	18.23	18.85	18.22	20.17
5.	Hydrogen as received	%	1.54	1.42	1.54	1.70
6.	Oxygen as received	%	5.46	5.05	5.47	6.02
7.	Nitrogen as received	%	0.32	0.30	0.32	0.35
8.	Combustible sulphur as received	%	2.7	3.2	2.9	2.4
9.	Volatiles from mineral substance as received	%	1.51	2.19	1.35	1.28
10.	Calorific value (LHV)	kcal/kg	1,410	1,315	1,400	1,590
		KJ/kg	5,910	5,510	5,860	6,660
11.	Volatiles combustible base	%		60 - 64		
12.	Hygroscopic moisture	%		11		
13.	Milling efficiency as per					
	-K			0.83 - 1.22		
	-for guaranteed coal			k = 1.1		
14.	Ash analysis					
	SiO_2	%		35 - 50		
	Al_2O_3	%		16 - 32		
	Fe_2O_3	%		7 - 20		
	MgO	%		1.5 - 3.5		
	CaO	%		2.5 - 5.0		
	SO_3	%		2.5 - 15		
15.	Ash Fusion Temperature					
	A. In oxidizing environment (by Leitz) for Analysis 1,2,3					
	-deformation point	t°C	1,250	1,220 - 1,300		
	-melting point	t°C	1,280	1,260 - 1,300		
	-running point	t°C	1,300	1,280 - 1,300		
	B. In semi-reduction environment (by Bunte-Baum) for Analysis 4					
	-deformation point,	t°C		1,050 - 1,150		
	-melting point,	t°C		1,150 - 1,300		
	-running point,	t°C		1,200 - 1,400		
16.	Density	gr/cub.cm		1.5 - 1.9		
17.	Bulk weight	kg/cub.m		700 - 1,100		

Table 4-2-1 Cement production Capacity of Each Plant

	Plant	Major Production Facility			Production (1,000 t/yr)		No. of Employee
		Raw Material Mill	Bake Kiln	Finishing Mill	Design Production	Actual Production	
1	Beli Izvor	Tube mill 4 units	Dry SP kiln 3 units (SP: suspension preheater)	Tube mill 4 units	1,500	700 ~ 800	1,100
2	Zlatna Panega	Tube mill 5 units	Dry SP kiln 5 units	Tube mill 5 units	1,000	600	1,000
3	Devnja	Tube mill 4 units, several small mills	Wet kiln 6 units	Tube mill 4 units small mill 5 units	1,800	1,100 ~ 1,200	1,500
4	Pleven	Tube mill 2 units	Dry SP kiln 2 units	Tube mill 4 units	300	200	600
5	Granitoid	Tube mill	Wet kiln 2 units	Tube mill 4 units	700	0 (Suspended)	900
6	Vulkan	Tube mill	Wet kiln 4 units	Tube mill 5 units	400	200	700
	Total				5,700	2,800 ~ 3,000	5,800

Table 4-2-2 Properties of Sampled Limestone

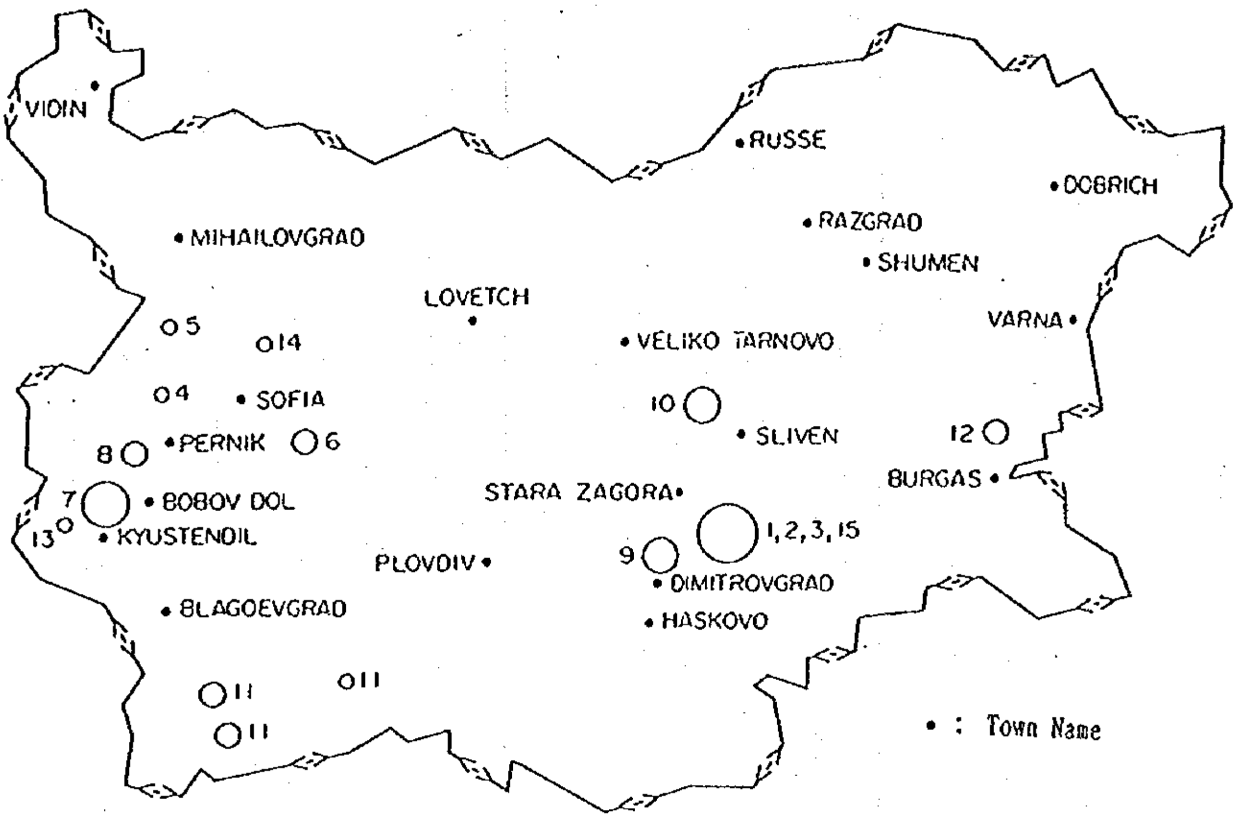
Unite (%)

Sampled Location	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	Ignition Loss (1,000°C)	Purity (as CaO)	Remarks
Bratyakunchevi	57.91	37.15	0.92	0.53	1.91	45.8	58.84	
Yurdere	54.0	0.16	<0.01	0.13	0.02	43.3	99.41	
Kamenets	54.0	0.38	<0.01	0.13	0.09	43.1	98.88	

(Reference) According to Appendix 3, 'Limestone analysis' in the Request for Development study by Bulgaria (Jan. 12, 1994), the original limestone analysis showed Ca: 38.8% and Mg: 0.1%. The following values are acquired after converting these values into CaO and MagO in the above table.

CaO: 54.32 (= 38.8 x 56／40)
MgO: 0.17 (= 0.1 x 40／24)

} These values are similar to those of the limestone from Yurdere.



I. POSITION:

1. TROYANOVO 1
2. TROYANOVO NORTH
3. TROYANOVO 3
4. BELI BREG
5. STANIANTSI
6. CHUKUROVO
7. BOBOV DOL
8. PERNIK
9. MARITSA BASIN
10. BALKAN BASIN
11. PIRIN
12. CHERNO MORE
13. BISTRITSA
14. ANTHRACITE
15. BRIKETNA FABRICA

II. COAL

LIGNITE : 1, 2, 3, 4, 5, 6, 9, 13

BROWN : 7, 8, 11, 12

BLACK : 10

ANTHRACITE : 14

III. MINES

OPEN : 1, 2, 3, 4, 5, 6, 7, 8, 11

UNDERGROUND : 7, 8, 9, 10, 11, 12, 13, 14

Figure 4-1-1 Locations of Coal Mines in Bulgaria

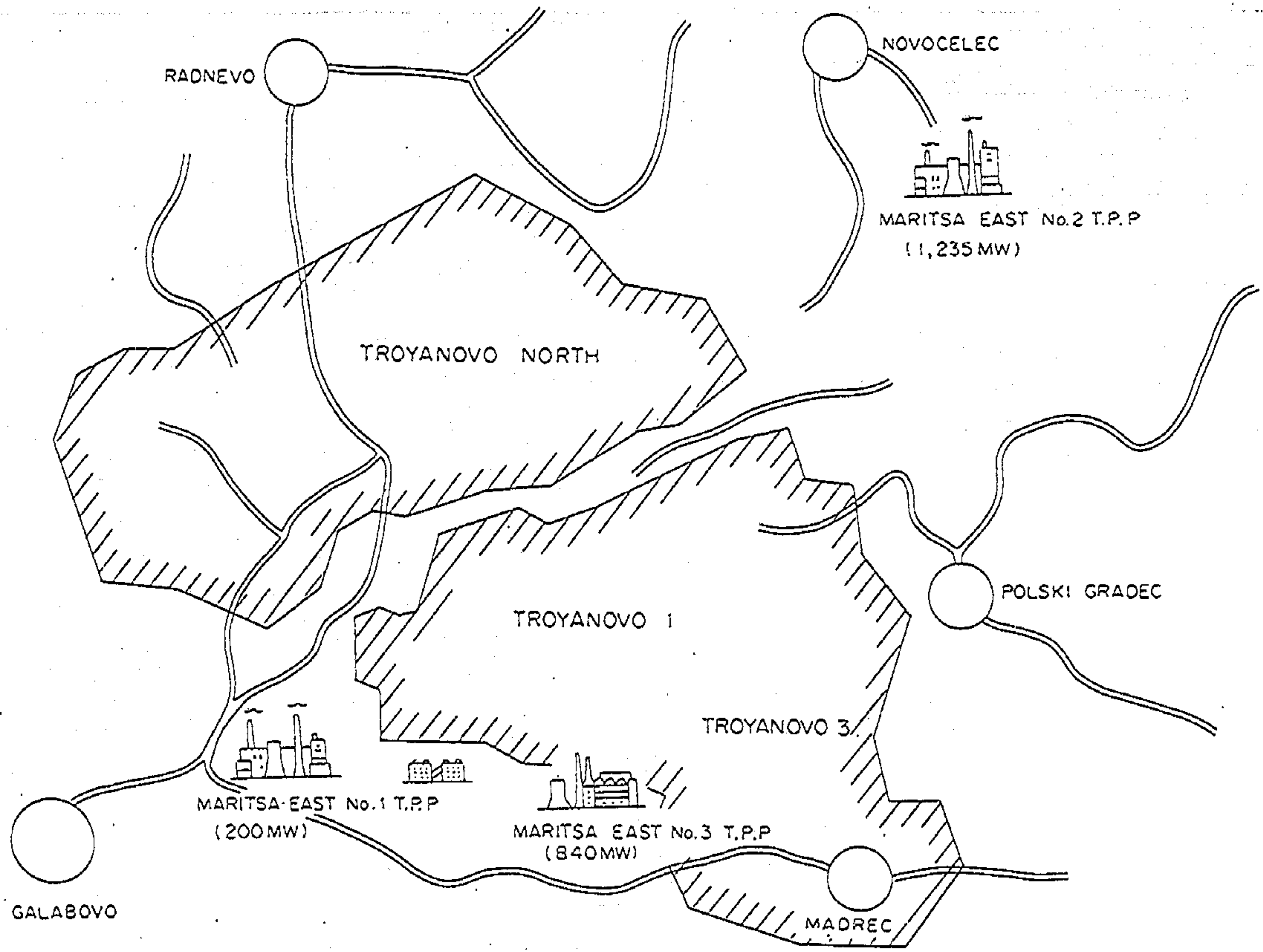


Figure 4-1-2 Locations of Coalfield and Power Stations in Maritsa East

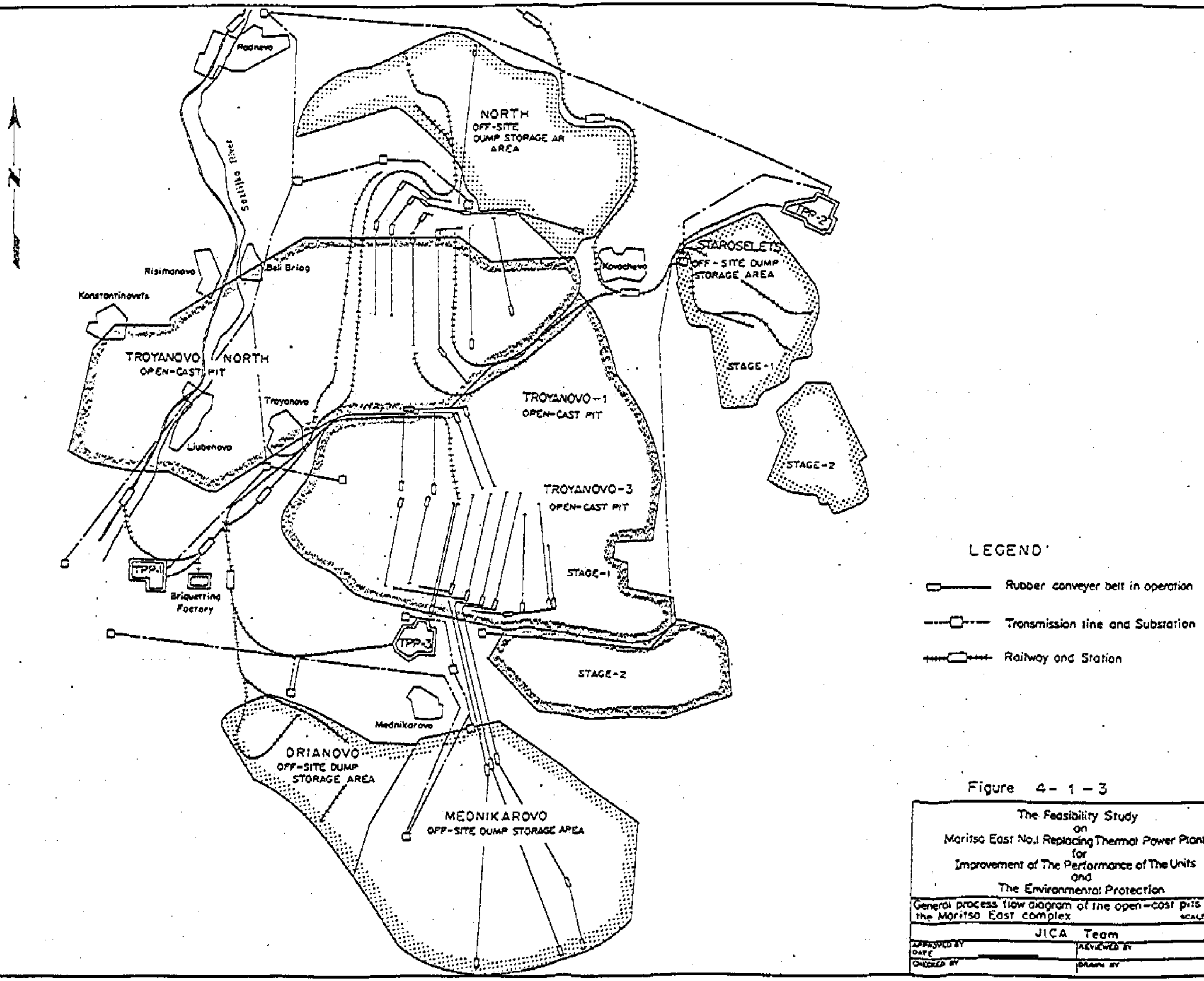


Figure 4-1-3

The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of The Performance of The Units
and
The Environmental Protection

General process flow diagram of the open-cast pits of the Maritsa East complex

SCALE:

JICA Team

APPROVED BY
DATE
REVIEWED BY
CHECKED BY
DRAWN BY

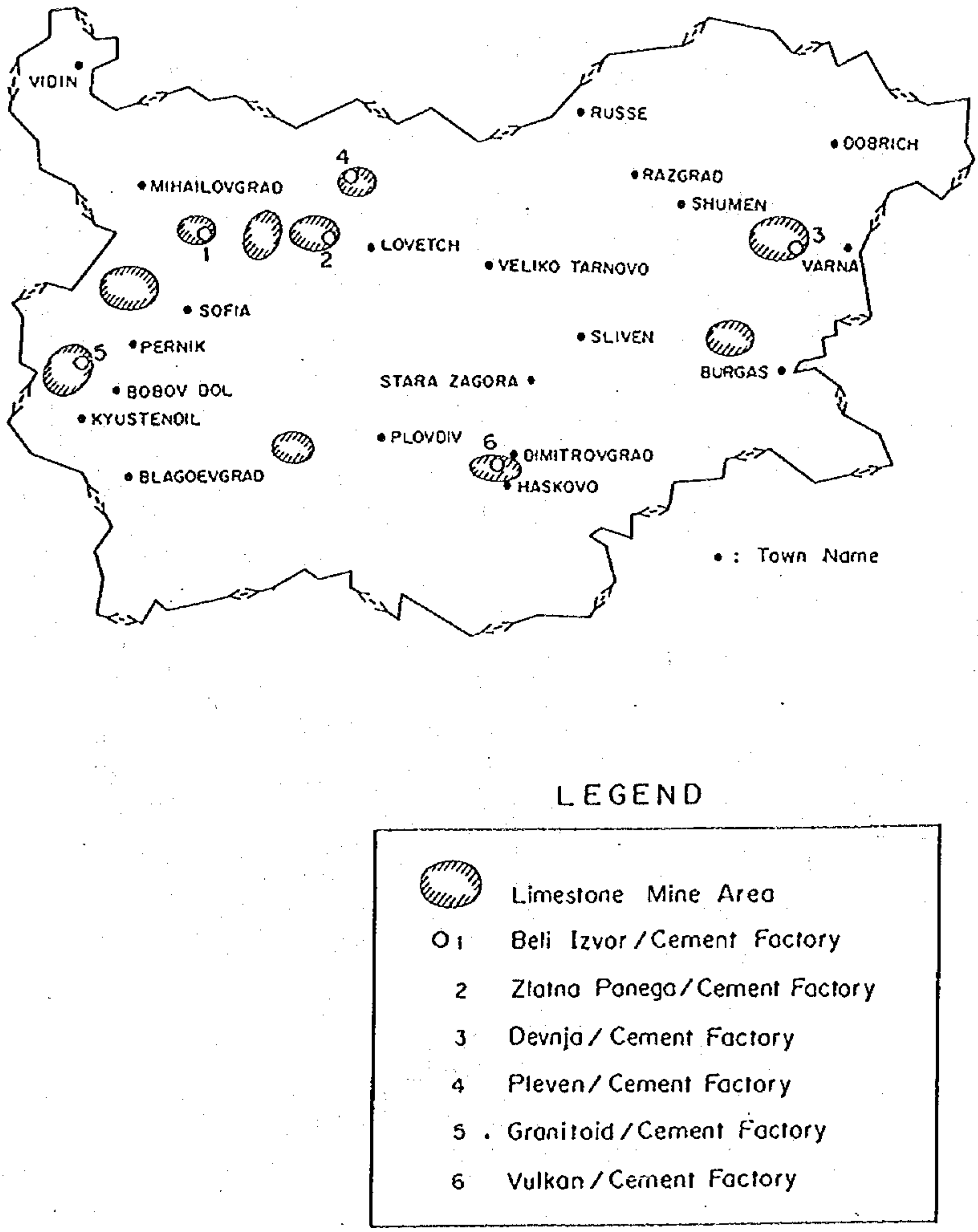


Figure 4-2-1 Locations of Limestone Mine and Cement Factory

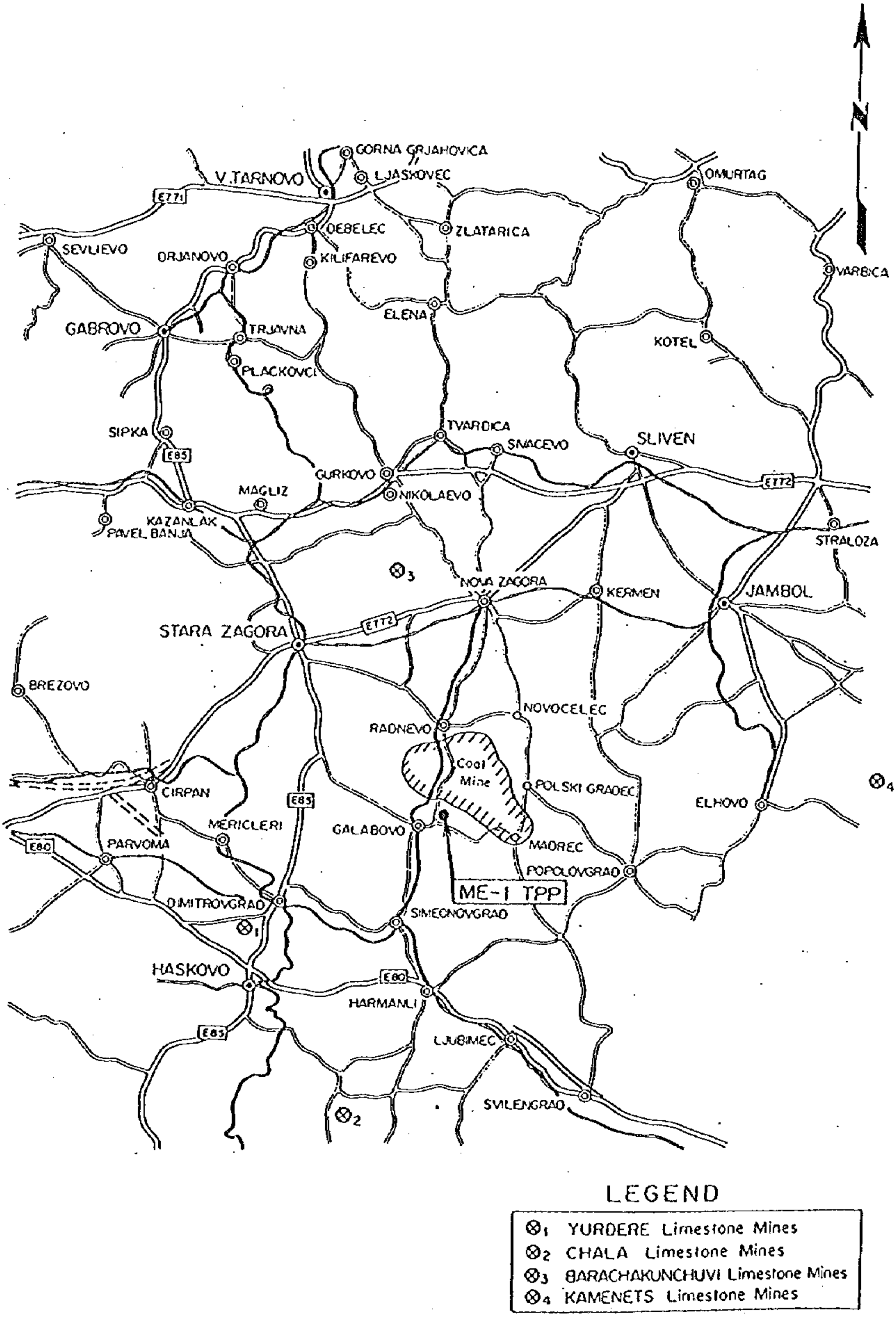


Figure 4-2-2 Locations of Limestone Mines

CHAPTER 5. OPTIMUM DEVELOPMENT PLAN

CHAPTER 5 OPTIMUM DEVELOPMENT PLAN

5.1 Matters for Consideration

Basic policy of plant design in terms of technology was consulted with NEK in detail. The basic items for design were determined as follows.

(1) Rated output: electric output 230MW x 2 units

(2) Hot water for local heating: 25Gcal/h.

Although hot water supply equipment for local heating is provided for both units, either of them is used for this purpose. At this time, electric output of a unit supplying hot water decreases depending on calorific value to be supplied.

(3) Steam condition

(a) Generated steam amount: 740 t/h (MCR)

Main steam pressure, temperature and reheated steam temperature are as shown below. They are generally used for natural circulation type boiler for power generation.

(b)	Main steam pressure:	169 kg/cm^2g (2,400 psig)	(at turbine inlet)
(c)	Main steam temperature:	538°C (1,000°F)	(at turbine inlet)
(d)	Reheated steam temperature:	538°C (1,000°F)	(at turbine inlet)

(4) Design lignite and ash properties

They are the same as values described in "SPECIFICATION OF MARITSA EAST LIGNITE BASIN/TROYANOVO2/AFTER1998 FOR MARITSA EAST-1 TPP" in Appendix 2 contained in Terms of Reference (dated January 12, 1995). The properties are shown in Table 5-1-1.

(5) Design limestone property

It is the same as values mentioned in "LIMESTONE ANALYSES" in Appendix 3 contained in Terms of Reference (dated January 12, 1995).

(6) Design heavy oil property

Existing heavy oil equipment will be used as they are. Table 5-1-3 shows the heavy oil property.

(7) Yearly plant availability: 70%

(8) Minimum load: 40%

(9) Emission gas standard

On the basis of O_2 = 6%, dry, the following restrictions shall be observed.

(a) SO_2: Less than 650mg/m^3N (227ppm) (Bulgarian standard value) or more than 90% of desulfurizing efficiency (EC standard when high sulfuric coal is used.)

(b) NOx: Less than 600mg/m^3N (292 ppm) (Bulgarian standard value)

(c) Dust: Less than 100mg/m^3N (Bulgarian standard value)

(d) CO: Less than 250mg/m^3N (200ppm) (Bulgarian standard value)

(10) Waste water standard

Class 3 of the Bulgarian standard "Index and standard to be applied to evaluation of the quality of surface flow water" (State Gazette Issue No.96, issued by Environmental Protection Committee of the Ministry of Health Care and Urban Project Committee) shall be followed.

(11) Overload

The following overload capacities are allowed.

(a) Boiler MCR: Less than 103% ECR

(b) Turbine TMF: Less than 105% rated output

(c) Generator: Less than 105% rated output

(12) Storage amounts of lignite and limestone

For 23 days according to the Bulgarian standard.

Table 5-1-1 Design Lignite Properties

Item			Guaranteed	A Max	W Max	Q Max
Ash	(air-dried base)	%	35.50	45.00	33.00	30.00
Moisture	(as received)	%	55.00	49.00	57.00	55.00
Ash	(as received)	%	15.98	22.95	14.09	13.50
Carbon	(as received)	%	18.23	18.85	18.22	20.17
Hydrogen	(as received)	%	1.54	1.42	1.54	1.70
Oxygen	(as received)	%	5.46	5.05	5.47	6.02
Nitrogen	(as received)	%	0.32	0.30	0.32	0.35
Combustible sulphur	(as received)	%	2.70	3.20	2.90	2.40
Volatiles from mineral substance (as received)		%	1.51	2.19	1.35	1.28
Calorific value (LHV)	kcal/kg kJ/kg		1,410 5,910	1,315 5,510	1,400 5,860	1,590 6,660
Volatiles		%	60 - 64			
Hygroscopic moisture		%	11			
Milling efficiency	per K per for guaranteed coal		0.83 - 1.22 K=1.1			
Ash analysis	SiO_2	%	35 - 50			
	Al_2O_3	%	16 - 32			
	Fe_2O_3	%	7 - 20			
	MgO	%	1.5 - 3.5			
	CaO	%	2.5 - 5.0			
	SO_3	%	2.5 - 15			
Ash fusion temperature A. In oxidizing environment (by Leits) for Analysis 1,2,3 Deformation point Melting point Running point B. In semi-reduction environment (by Bunte-Baum) for Analysis 4 Deformation point Melting point Running point		 °C °C °C °C °C °C	 1,250 1,280 1,300	 1,210 - 1,300 1,260 - 1,300 1,280 - 1,300 1,050 - 1,150 1,150 - 1,300 1,200 - 1,400		
Density	gr/cub. cm		1.5 - 1.9			
Bulk weight	kg/cub. cm		700 - 1,000			

Table 5-1-2 Design Limestone Properties

Original limestone analysis (air dried base)	Ca (%)	38.8
	Mg (%)	0.1
	C (%)	11.94
	S (%)	0.004
Fraction analysis between 0.125 - 0.250 mm (air dried base)	Ca (%)	39
	Mg (%)	0.1
	C (%)	11.94
	S (%)	0.003

Limestone specification	Grade	Reactive Index RI (mol/mol)	Adsorption Capacity CI (Limestone gs/kg)
	excellent	< 2.5	120 <
	good	2.5 - 3.0	100 - 120
	medium	3.0 - 4.0	80 - 100
	low	4.0 - 5.0	60 - 80
	bad	5.0 <	< 60

Table 5-1-3 Heavy Oil Properties

Item		Bulgarian Standard	Acceptable Properties
Calorific value [HHV]	MJ/kg Kcal/kg	39.8 9,506	39.88 9,525
Kinematics viscosity	mm^2/s	115	—
Density	g/cm^3	1.015	0.968
Ash content	Weight %	0.15	0.068
Sulfur content	Weight %	3.5	2.99
Moisture	Volume %	1.0	—
Impurities	Weight %	0.5	—
Flash point	℃	110 or more	120 or more
Pour point	℃	25 or less	7 or less

5.2 Selection of Boiler Type

5.2.1 Boiler Types

A type of a boiler to be replaced is selected considering the following points.

(1) This plant has already experienced commercial power generation.

(2) The standard for emission gas can be observed.

(3) The replacing boiler can suit the property of lignite.

When selecting an optimum boiler type satisfying these requirements, the following three types should be compared.

(a) Circulating fluidized bed combustion boiler (C-FBC)
(b) Bubbling fluidized bed combustion boiler (B-FBC)
(c) Pulverized coal fire boiler (PCF) + Flue gas desulfurizer (FGD)

5.2.2 Conceptual Design of Boiler Types

Table 5-2-1 shows a result of comparison in terms of these three boiler types. Table 5-2-2 shows a result of a case designed with ash max. coal. The features and differences among these boilers are as follows.

(1) Circulating fluidized bed combustion boiler (C-FBC)

(a) According to actual results, most commercial boilers are medium or small capacity types. Lignite burning units are found in a great number. The biggest capacity of currently operating boilers firing lignite is 250MW.

Because of low heat amount and high moisture in lignite, gas volume in this 230MW unit is on the same level of 400MW firing bituminous coal. Design of the cyclone is one of important points in this type boiler particularly in a large capacity unit.

(b) As for obedience to emission gas standard, desulfurization within a furnace is possible due to contact between combustion gas and limestone to be accelerated. Ca/S is more than 2 and desulfurization efficiency is more than 90%. Additionally, because of small amount of nitrogen in fuel and lower temperature of combustion in the furnace, NOx emission restriction of Bulgarian standard can be observed.

(c) As for construction cost and operation cost, this equipment requiring no desulfurizer and having excellent boiler efficiency is the most economical.

(2) Bubbling fluidized bed combustion boiler (B-FBC)

(a) Although there are a large number of boilers practically used for commercial purpose, most of them are of small capacity type. The maximum capacity unit currently operating is a bituminous coal fired one for 350MW, but there is no large capacity unit firing lignite. This is a method for combustion within a fixed fluidized bed, designing a coal supplying system in which fuel and lignite are fed uniformly into a layer is important.

Coal supplying method is classified to "bottom feeding method" in which fuel is uniformly fed by air from the bottom of the furnace into a layer and "upper supplying method" in which fuel is sprayed over the layer.

However, high water content fuel such as lignite produced in Bulgaria easily produces clogging by "bottom feeding method" and, in the case of the "upper feeding method", the large capacity machine cannot scatter fuel uniformly over the bottom of the furnace. Basic development of stabilized coal feeding system is necessary, thus the "upper feeding method" is considered to be technologically unapplicable.

(b) As for obedience to the emission gas standard, this is a method for combustion within a fixed fluidized bed in the furnace, so that desulfurization within the furnace is possible due to contact between combustion gas and limestone in the furnace. Although consumption of limestone increases as desulfurizing material not to make dust recirculate as compared with the C-FBC, a performance in which desulfurization efficiency is more than 90% can be obtained with Ca/S of more than 2.5.

Because of small amount of nitrogen in fuel and lower temperature of combustion in the furnace, necessity of a desulfurizer does not exist. NOx emission restriction of Bulgarian standard can be observed without DeNOx equipment.

(c) Although thermal power by bituminous requires installation of a secondary furnace to improve combustion efficiency in order to prevent dust containing unburnt component accompanied by combustion gas flow from recirculating, it is possible to obtain an excellent combustion efficiency without installation of carbon burn up cell (CBC) because its fuel ratio is so low that it is easy to burn. Thus, the boiler construction can be simplified.

(d) As for construction cost and operation cost, although no desulfurizer is required, this equipment having lower efficiency than the C-FBC is economical next to the C-FBC.

(3) Pulverized coal fire boiler (PCF) + Flue gas desulfurizer (FGD)

(a) There are a large number of boilers practically used for commercial purpose and its reliability has been established by the existing technology. The maximum lignite-fired unit currently operating is 600MW. As for desulfurizer, the wet limestone-gypsum method has accumulated a number of actual achievements as commercial machine as even a large capacity machine.

Although there is no achievement with high sulfur content like lignite produced in Bulgaria, its reliability has been established by existing technology, so that it is considered to be technologically applicable. However, sulfuric acid dew point increases because of high sulfuric content and water content in fuel, therefore it is necessary to maintain gas temperature from boiler exit to desulfurizing intake high. Consequently, reduction of boiler efficiency is remarkable.

(b) As for obedience to the emission gas standard value, because the boiler unit has no desulfurizing function, installation of desulfurizer is necessary. However, a performance in which desulfurizing efficiency is more than 90% can be obtained by installing the wet limestone-gypsum desulfurizer. Although water to be supplied to the wet type desulfurizer is necessary, necessary amount of desulfurizing agent can be minimized.

(c) As for construction cost and operating cost, the construction cost of the boiler is cheap, however, the boiler efficiency is low. Consequently, this equipment which requires a desulfurizer is the worst in terms of economic efficiency.

5.2.3 Study Result of Power Plant Layout

Figure 5-2-1 to 3 show examples of power plant layout.

(1) Basic plan of the layout

A study result of the entire project is shown below and it is applicable regardless of boiler type.

(a) Location of a replacing plant

The area for old unit nos. 5 and 6 is not big enough to install replacing units R1 and R2 and the existing lignite dryers will be interfered. The area shall be extended by about 58m to the north.

(b) Application of the existing 180m high stack

The 180m high stack used in the old unit nos. 5 and 6 will interfere with an electrostatic precipitator and disturb future extension of the facility. Therefore, it is difficult to reuse the stack. Thus, a new stack will be built on an optimum position.

(c) Application of the existing 120m high stack

The 120m high stack for old dryers is not high enough from "down draft effect" prevention point of view. To avoid the effect, a boiler building will be forced to be limit to 70 m. Further, because the diameter of the stack exit is small, the stack is not sufficient for the gas amount produced by this project. Thus, the effective use of this stack cannot be expected.

(d) Allocation of coal storage place and limestone storage place

A coal storage place currently used is not enough for storage of coal and limestone for a 23-day operation of this plant. Thus, a reclaimed place by ash disposal will be allocated.

(e) Existing disposed ash transportation pipe system

Ash transportation pipe lines currently used interfered will be with a newly built stack even if any type of boiler is selected. Thus, it is necessary to move the pipe line system to other place. A new route of the pipe system should be decided at the implementation stage.

(2) Basic plan of layout for each boiler type

A result of consideration on the large difference due to boiler type is shown below.

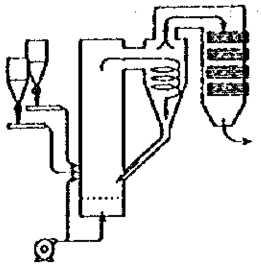
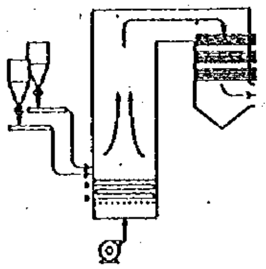
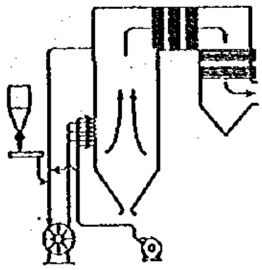
(a) Waste water treatment equipment

The capacity of waste water treatment for the FBC is smaller than that for the PCF, the waste water treatment equipment can be located between a newly built stack and a lignite transportation route. On the other hand, in the PCF + FGD, its waste water treatment amount is larger, because waste water from a desulfurizer should be treated. Thus a waste water treatment place needs to be installed in the coal storage place of the old unit nos. 5 and 6.

5.2.4 Result of Consideration on Selection of Boiler Type

As a result of above mentioned studies, the C-FBC and PCF + FGD are technologically applicable to a replacing plant, but, the C-FBC is eligible because of economical efficiency. Thus, the C-FBC only will be further studied.

Table 5-2-1 Comparison of boiler types

Item	C-FBC	B-FBC	PCF + FGD
(Comparison of technologies) 1. Structure (Overall)			
2. Principle	Bed material is fluidized by air at sufficient velocity to jump out and returns to the furnace through the cyclone placed upstream of heat-recovery area. Fuel is injected into fluidized bed material to burn. Combustion temperature is kept lower.	Bed material is fluidized by air under bubbling condition. Fuel is injected into bubbling bed and burnt by contact with bed material and combustion temperature is kept lower.	Solid fuel is dried with hot gas and simultaneously pulverized through water will, and then delivered to furnace where fuel is burnt at high temperature.
3. Fuel (1) Coal	Lignite, Subbituminous coal, Bituminous coal, Anthracite Oil cokes, Wood chips, RDF	Lignite, Subbituminous coal, Bituminous coal, Oil coke, Wood chips, RDF	Lignite, Subbituminous coal, Bituminous coal, Anthracite
(2) Diameter	0.1-12mm	3-20mm	0-10mm (Lignite) 75% or more should pass through a 200 mesh. (Bituminous-anthracite)
(3) Surface moisture content	Must be small not to cause difficulty in fuel supply.	Must be small not to cause difficulty in fuel supply.	Must be small not to cause difficulty in fuel supply not interfere fuel supply.
4. Bed material	Silica sand, Coal ash, Limestone	Silica sand, Coal ash, Limestone	—
5. In-furnace desulfurizing agent	Limestone 1-3mm	Limestone 1-3mm	—
6. Performance (1) Combustion temperature	770 ~ 860°C	770 ~ 860°C	1,300 ~ 1,500°C
(2) Air excess rate	1.20 ~ 1.25	1.20 ~ 1.30	1.20 ~ 1.25
(3) Combustion efficiency	~99%	~94%	~99%
(4) Measure against SOx •Desulfurization	In-furnace desulfurization with limestone	In-furnace desulfurization with limestone	Wet type limestone-gypsum process (externally installed)
•Desulfurization ratio	> 90%	> 90%	> 90%
•Ca/S	2.0 ~ 3.0	2.5 ~ 3.5	1.05 ~ 1.1
(5) Measures against NOx •Denitration	NOx control through combustion measures (low temperature combustion and staged combustion)	NOx control through combustion measures (low temperature combustion)	NOx control through combustion measures (low NOx burner and staged combustion)
(6) Load change rate	3%/minute	3%/minute	3%/minute
(7) Min. load for single fuel firing	40% MCR	40% MCR	40% MCR
(8) Other characteristics	•Lower gas temperature at GAH outlet. •Easy control of furnace temperature •Slower growth of scale on evaporating tube. •No slagging due to no ash melting.	•Lower gas temperature at GAH outlet. •Slower growth of scale on evaporating tube. •No slagging due to ash melting. •Tube in bed susceptible to wear.	•Higher gas temperature at GAH outlet. •Scale may grow on FGD because of ultra-high S content coal. •Somewhat good adaptability to change in the property of fuel •Be cautious of slagging and fouling.

Item	C-FBC	B-FBC	PCF + FGD
7. Difference in components			
(1) Combustion furnace	Waterwall or waterwall plus firebrick wall	Waterwall	Waterwall
•Gas velocity	4.5 ~ 15 m/s	1.2 ~ 2.4 m/s	—
•Residence time	3 ~ 5 sec	3 ~ 5 sec	1 ~ 1.5 sec
(2) Fuel supply system	Fuel is supplied by air transfer directly or through the circulating line into the furnace bottom.	Distribution over the upper bed only on smaller units (large granule fuel is used to prevent scattering), but air transfer blow in the bed on larger units.	Dried fine coal particles from the mill is supplied transfer to coal burnes by drying gas.
(3) Pretreatment system for coal	Coal storage yard → grid + crusher → Raw coal bunker *Measures against clay ingress •Quality control at coal mine. •Setting up a clay removing system. *Measures against bunker blocking •Minimum storing amount •Bunker angle ≥ 70°	Coal storage yard → grid + crusher → Raw coal bunker *Measures against clay ingress •Quality control at coal mine. •Setting up a clay removing system. *Measures against bunker blocking •Minimum storing amount •Bunker angle ≥ 70°	Coal storage yard → grid + crusher → Raw coal bunker *Measures against clay ingress •Quality control at coal mine. •Setting up a clay removing system. *Measures against bunker blocking •Minimum storing amount •Bunker angle ≥ 70°
(4) Others	•Increase the number of cyclone. •Suitable design for keeping uniform gas flow (furnace and cyclone arrangement) •Largest scale furnace but within conventional scale-up range	—	—
8. History and applications			
(1) Year when systems were developed	1980s	1970s	1960s
(2) Number of systems installed	About 300 (medium and small capacity units)	Several thousands (mostly small capacity units)	Many (mostly 200-600MW class)
(3) Large capacity experience (lignite fired)	Currently in operation 250MW (Provence/France) Under construction 235 MW/681 t/h (Poland)	Currently in operation 350MW (Japan) (Bituminous coal)	Currently in operation 600MW (Germany) Under construction 350MW (SOx=4753ppm/Spain)
(4) Future (lignite fired)	Study has been completed on 400 to 600 MW class *No experience for lignite burning of 740 t/h, but the design is within applicable range.	Study has been completed for 1300 t/h class. *No experience of lignite fired 740 t/h unit.	— *No experience of large FGD with ultra high concentration (SO_2 in gas: 5000 to 6000ppm). (At ME-2, FGD is scheduled to start operation after three years.)
9. Technology level	Δ •Medium and small capacity units are in commercial use. •Few experience of large capacity units.	Δ •Medium and small capacity units are in commercial use. •Few experience of large capacity units.	Δ •PCF is commercially used. •No experience of FGD with ultra-high S content coal.
10. Reliability	Δ •Confirmation of cyclones' performance, and measures against erosion of cyclones, side wall tubes and heat exchanger tube are required. •No experience with Bulgarian lignite. Technology development is required.	Δ •A reliable coal feeding system is required. •Measures against erosion of side wall tubes and heat exchanger tubes in bed. •No experience with Bulgarian lignite. Technology development is required.	Δ •Measures against corrosion, erosion and scaling of FGD are required. •No experience of FGD with ultra-high S content coal. Technology development is required.

Item	C-FBC	B-FBC	PCF + FGD
11. Operating characteristics	Δ	Δ	O
(1) Adaptability to load change	Good	Good	Good
(2) Operatability	Good when combustion in the furnace is stabilized after start up.	Good when combustion in the furnace is stabilized after start up.	Good. But be cautious of scaling of FGD
(3) Time required for start-up	Longer than PCF	Longest	Shortest
(4) Stability	Good	Somewhat poor	Good
12. Maintenance	Δ •Measures against erosion and repair are required.	Δ •Measures against erosion and repair are required.	Δ •Measures against FGD erosion and corrosion repair are required. •Scale must be removed from the tower and pipe.
13. By-products			
(1) Type	Mixed (limestone + gypsum + raw limestone)	Mixed (limestone + gypsum + raw limestone)	Separated (Coal ash, gypsum)
(2) Disposal	Disposed to ash disposal area •Measures against increase of temperature and caking caused by reaction with Ca and water are required. Cautions must be taken in handling. •Could be used for separating underground water utilizing its low penetrating property (To be distributed in the bottom of ash disposal area).	Disposed to ash disposal area •Measures against heat and caking generated from Ca and water mixture are required. Cautions must be taken in handling. •Could be used for separating underground water utilizing its low penetrating property (To be distributed in the bottom of ash disposal area).	Disposed to ash disposal area •Easy to review effective use. •Measurement against caking generated from gypsum and water is required. Cautions must be taken in handling.
14. Utility	[70% of utilization rate]	[70% of utilization rate]	[70% of utilization rate]
(1) De-SOx sorbent:	Limestone ($CaCO_3$) 520 x 10^3 t/y	Limestone ($CaCO_3$) 830 x 10^3 t/y	Limestone ($CaCO_3$) 290 x 10^3 t/y
(2) Amount of fed water	450x10^3 t/y	520x10^3 t/y	1,120x10^3 t/y
(3) Auxiliary power consumption	6 ~ 7%	7 ~ 8%	8 ~ 9%
15. Waste water	General waste water + water treatment drainage	General waste water + water treatment drainage	General waste water + water treatment drainage + FGD drainage
16. Stack lining or heating of flue gas	Lining: Required *Take account of acid dew point	Lining: Required *Take account of acid dew point	Lining: Required Heating: Required *Take account of acid dew point
17. Space for installation	O •Smaller than PCF+FGD •May be installed in space provided. (The area for Nos. 7 to 10 boilers. North space. Existing ash disposal area. The area for drier for Nos.7 to 10 boilers)	O •Smaller than PCF+FGD •May be installed in space provided. (The area for Nos. 7 to 10 boilers. North space. Existing ash disposal area. The area for drier for Nos.7 to 10 boilers)	O •Larger than FBC •May be installed in space provided. (The area of Nos. 7 to 10 boilers. North space. Existing ash disposal area. The area of drier of Nos.7 to 10 boilers)
18. Time required for construction	Ordinary time schedule Time for trial run may take longer because of absence of experience with lignite firing system on equivalent capacity.	Ordinary time schedule Time for trial run may take longer because of absence of experience with lignite firing system on equivalent capacity.	Ordinary time schedule Coordination is required with boiler side during a trial run because of absence of experience in operating FGD with ultra-high S content coal.
19. Environmental considerations	O •Compliance with emission standards. •Few waste water from boilers. •No facilities that may cause problems for noise or vibration.	O •Compliance with emission standards. • Few waste water from boilers. •No facilities that may cause problems for noise or vibration.	O •Compliance with emission standards. •A large scale waste water treatment equipment is required for FGD waster water and drainage. •No facilities that may cause problems for noise or vibration.
Technical evaluation	Adaptable Environmental protection measures are adequate, but technological development on operation and maintenance is required for lack of operation experience with Bulgarian lignite.	Difficult to adapt. A coal feed system design for the high moisture content coal such as Bulgarian lignite is not established yet.	Adaptable Environmental protection measured are adequate, but technological development is required for lack of experience with large scale systems of FGD with ultra-high S content coal.

Item	C-FBC	B-FBC	PCF + FGD
Comparison of economy *( ) Index 1. Cost for facilities	605.3 M$ (90)	645.5 M$ (97)	665.9 M$ Base (100)
2. Operating (fix, variable) cost	4.9 ¢/Kwh (92)	5.2 ¢/Kwh (98)	5.3 ¢/Kwh Base (100)
Economical estimation	Good	Fairly good	Base
Overall evaluation	◎ Equivalent to PCF+FGD although technological development is required. Best in economy.	Δ A coal feed system for stable B-FBC operation is complex. So coal feed system design for the high moisture content coal such as Bulgarian lignite is not established.	O Equivalent to C-FBC but technological development is required for FGD. Cost is high.

Table 5-2-2 Planned Performance

(per 1unit)

1. Boiler type		C-FBC	B-FBC	PCF+FGD
2. Coal		Ash MAX	Ash MAX	Ash MAX
3. Plant efficiency (wet low calorie base)	%	36.5	34.5	32.8
Boiler efficiency	%	87.6	82.6	80.4
Turbine efficiency	%	45.0	45.0	45.0
Auxiliary power consumption	%	7.0	9.0	9.0
Plant loss	%	0.3	0.3	0.3
4. Plant efficiency (wet high calorie base)	%	28.5	26.9	25.6
Boiler efficiency	%	68.3	65.2	62.7
Turbine efficiency	%	45.0	45.0	45.0
Auxiliary power consumption	%	7.0	8.0	9.0
Plant loss	%	0.3	0.3	0.3
5. Coal consumption (wet base)	T/H	412	436	458
	T/D	9,888	10,464	10,992
(annual plant utilization = 70%)	$\times 10^3$T/Y	2,526	2,674	2,808
6. Limestone consumption	T/H	85	112	47
	T/D	2,040	2,688	1,128
(annual plant utilization = 70%)	$\times 10^3$T/Y	521	687	288
Surplus rate	—	2.0	2.5	1.05
7. Make up water	T/H	73	80	182
For plant using	T/H	73	80	45
For FGD using	T/H	—	—	137
	T/D	1,752	1,920	4,368
(at plant annual utilization = 70%)	$\times 10^3$T/Y	448	491	1,116
8. Ash disposal quantity	T/H	225	255	127
	T/D	5,400	6,120	3,048
(annual plant utilization = 70%)	$\times 10^3$T/Y	1,380	1,564	779
9. By-product gypsum	T/H	—	—	87
	T/D	—	—	2,088
(annual plant utilization = 70%)	$\times 10^3$T/Y	—	—	533
10. Boiler outlet flue gas				
Wet base	$\times 10^3$m^{3}N/H	1,294	1,473	1,484
Dry base	$\times 10^3$m^{3}N/H	978	1,137	1,131
Gas temperature	°C	165	165	195
11. Flue gas properties at stack outlet				
Wet base	$\times 10^3$m^{3}N/H	1,297	1,477	1,666
Dry base	$\times 10^3$m^{3}N/H	981	1,140	1,191
Gas temperature	°C	170	170	90
SO_2	mg/m^{3}N	2,687	2,436	1,384
NOx	mg/m^{3}N	<600	<600	<600
Dust	mg/m^{3}N	<100	<100	<100
CO	mg/m^{3}N	<250	<250	<250

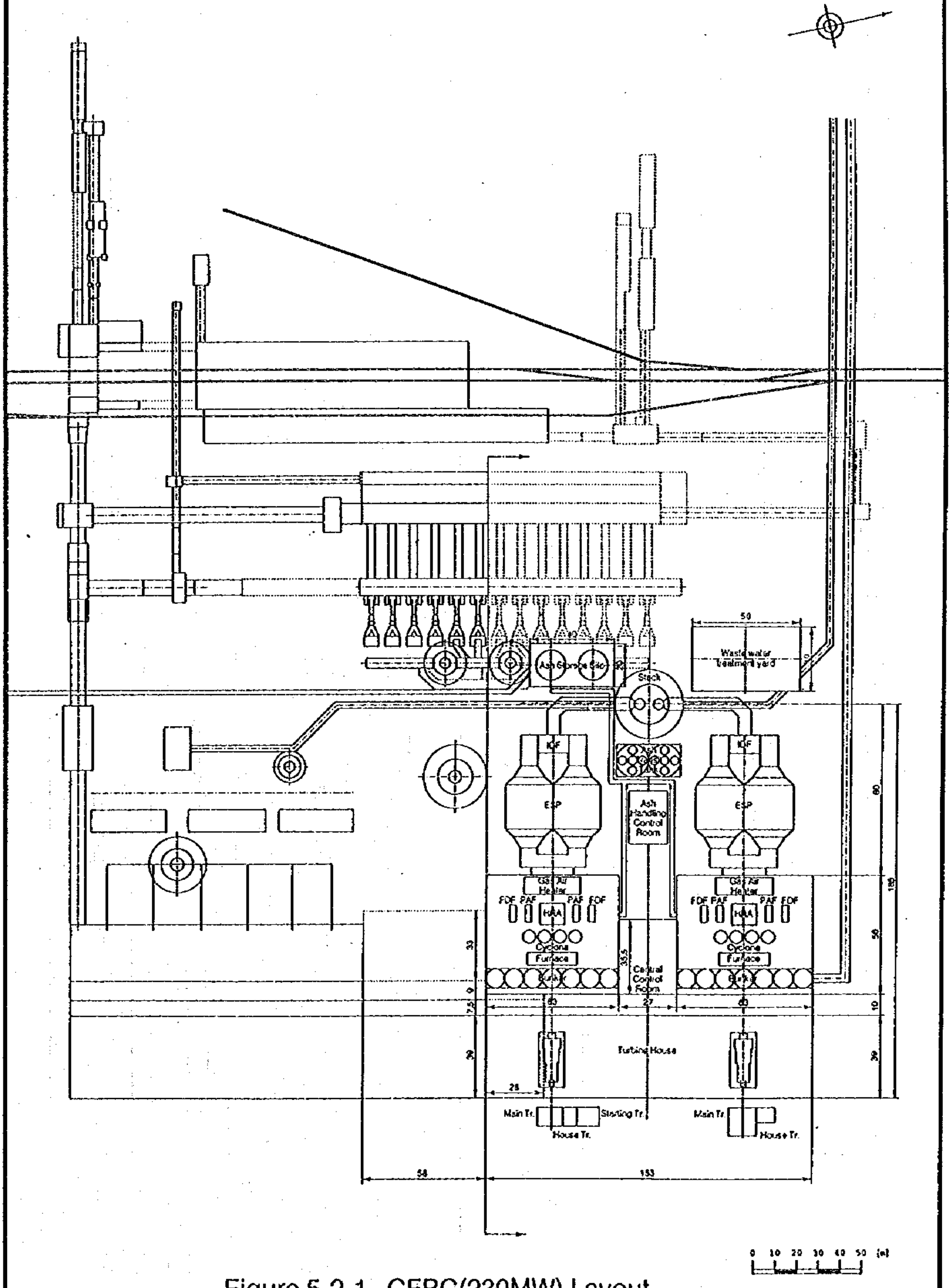


Figure 5-2-1 CFBC(230MW) Layout

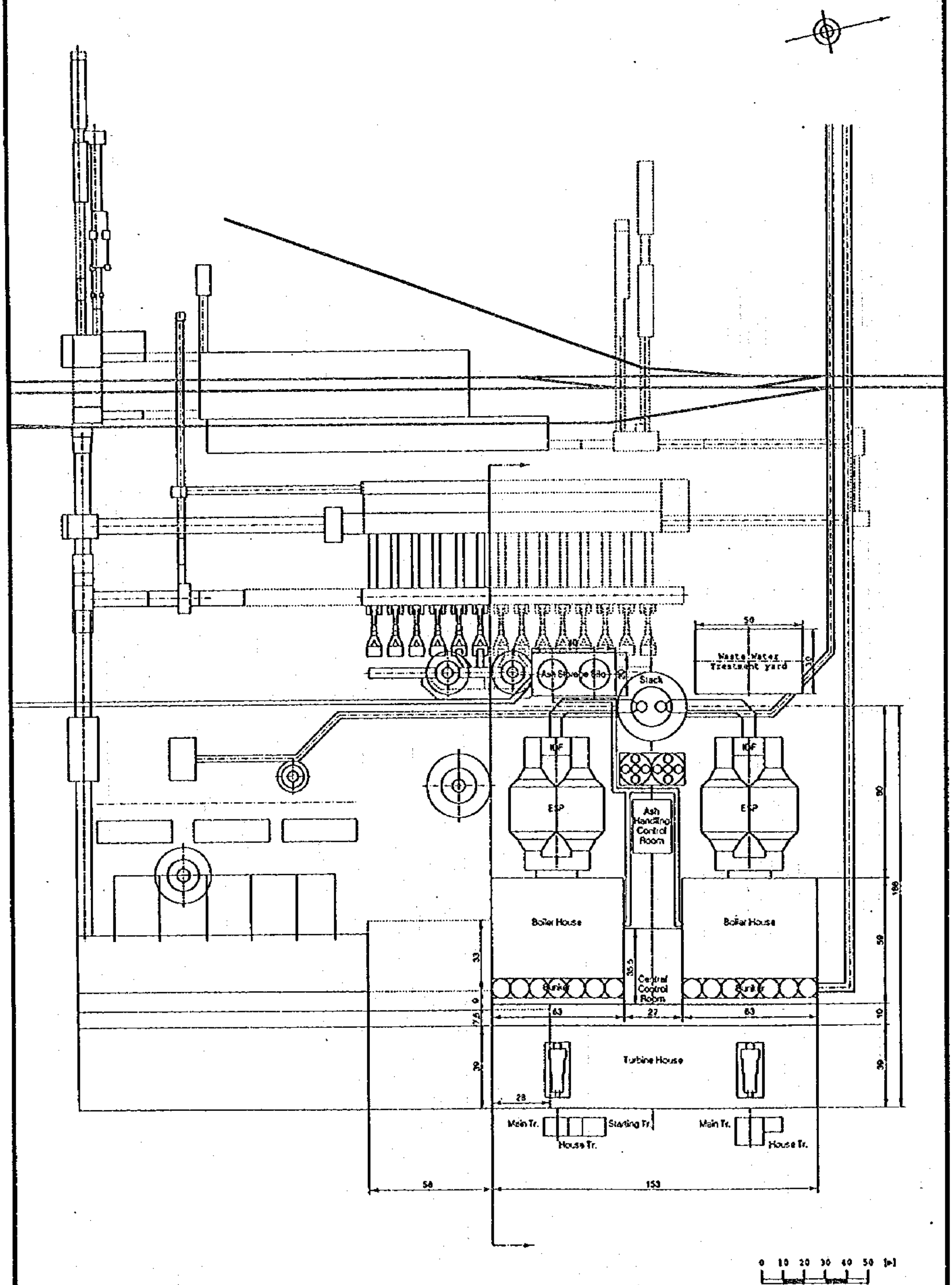


Figure 5-2-2 BFBC(230MW) Layout

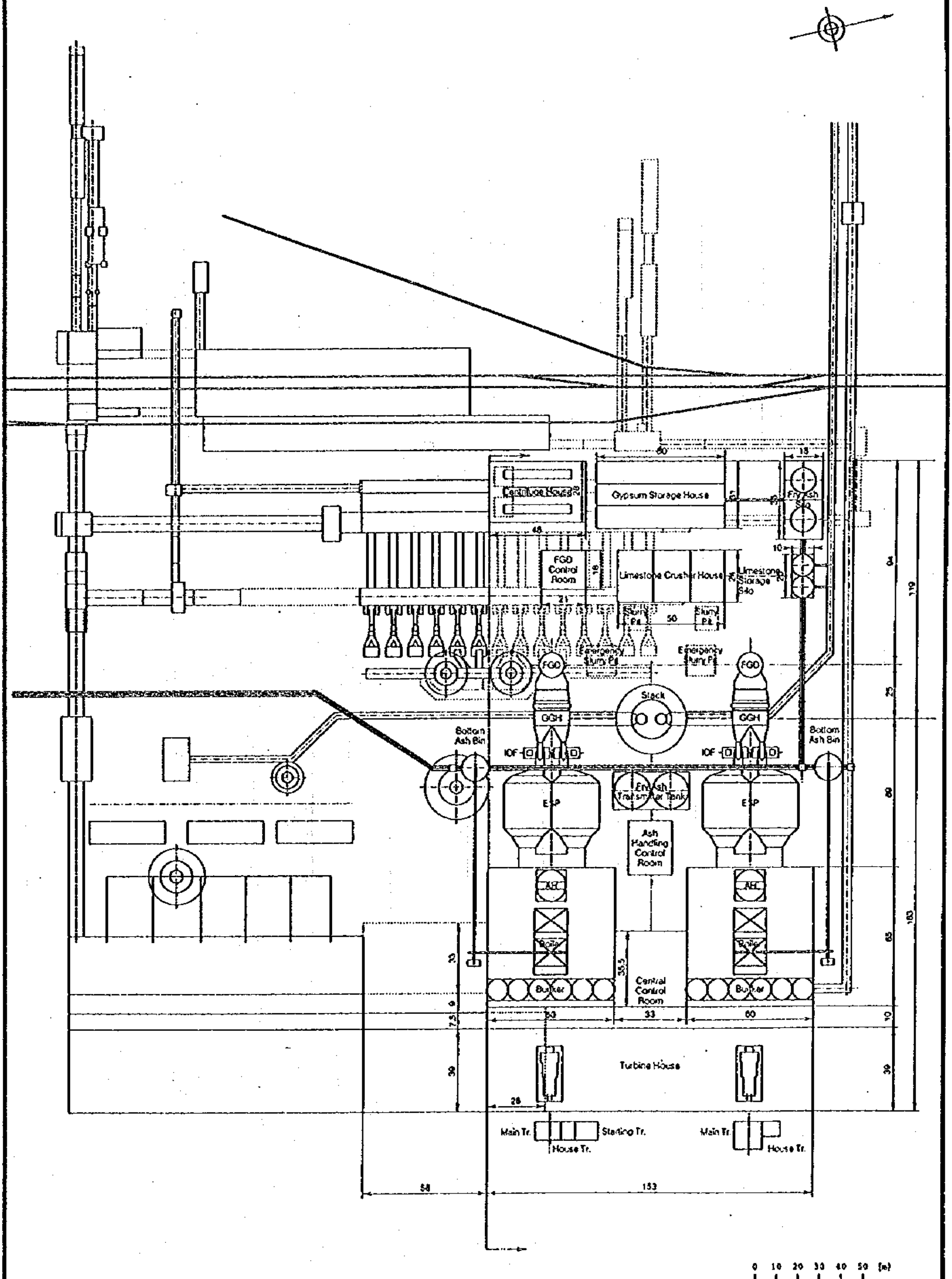
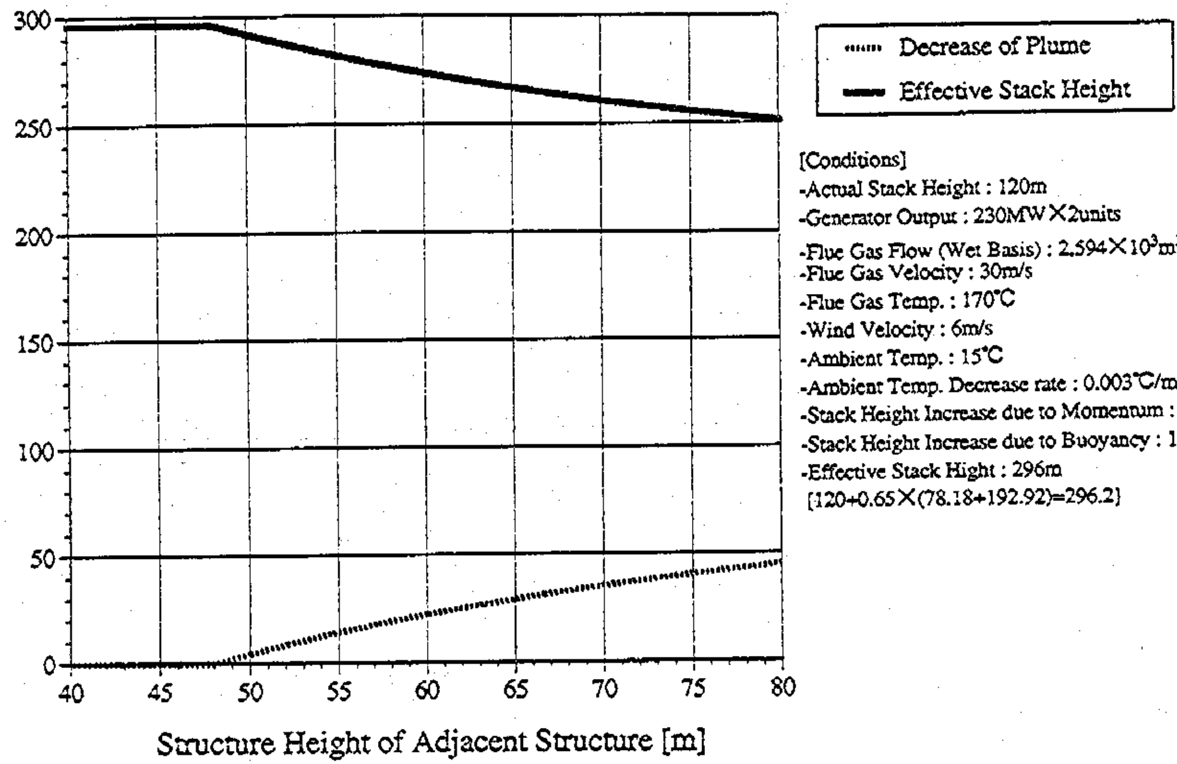


Figure 5-2-3 PCF+FGD(230MW) Layout



[Conditions]
- Actual Stack Height : 120m
- Generator Output : 230MW × 2units
- Flue Gas Flow (Wet Basis) : 2.594 × $10^3 m^3N/H$
- Flue Gas Velocity : 30m/s
- Flue Gas Temp. : 170℃
- Wind Velocity : 6m/s
- Ambient Temp. : 15℃
- Ambient Temp. Decrease rate : 0.003℃/m
- Stack Height Increase due to Momentum : 78.18m
- Stack Height Increase due to Buoyancy : 192.92m
- Effective Stack Hight : 296m
[120+0.65×(78.18+192.92)=296.2]

Figure 5-2-4 Effective Stack Height vs. Adjacent Structure Height on a 120m High Stack, ME-1 P/S

5.3 Selection of Type of Steam Turbine and Generator

5.3.1 Selection of Type of Steam Turbine

It is recommended that the following type of turbine is adopted for this replacing project.

- Type of Steam Turbine: Tandem compound, two casing, double flow (TCDF).

5.3.2 Selection of Type of Generator

It is recommended that the following type of turbine is adopted for this replacing project.

- Type of Generator: Hydrogen-cooled, horizontal-shaft cylindrical revolving magnetic field, explosion-proof, 3 phase AC Generator.

5.4 Existing Equipment and Facilities which can be Reused

5.4.1 Intake and Discharge Facilities

(1) Screen Pump Room

The existing screen pump room can be reused because there is seen no deterioration on its structure.
However, the following two foundations should be modified.

(a) Screen section

To replace the aged screen with a new one, it will be necessary to modify all the guide walls for the screen equipment on the concrete side face.

(b) Pump section

To replace the aged pump with a new one, its will be necessary to modify all the concrete slabs for the pump installation section in accordance with its installation manual.

(2) Intake Waterway

The proposed intake waterway route including the existing section to be reused and the section to be constructed newly is presented in Figure 5-4-1-1.

(a) Existing waterway

There are two existing waterways, and each consists of a circular concrete culvert with a length of 175 m and a directly buried steel pipe with a length of 225 m.

(b) Study on possibility to reuse the existing circular concrete culvert section

Although the soundness of the culvert section has not been diagnosed for more than thirty-five (35) years after installation, the possibility of reusing the existing concrete culvert section was studied from structural point of view on the assumption that the existing concrete would be sound for the time being.

1) Results of study and evaluation thereof

Since the specifications are not clear, this study has been carried out on the following two cases; the amount of reinforcing bars used is ϕ 10 ctc 150 or ϕ 10 ctc 300.

Cases			Case 1	Case 2
Reinforcing bars used		mm	ϕ 10 ctc 150	ϕ 10 ctc 300
Sectional dimension	B	cm	100	
	H	cm	25	
Sectional force	M	tf.m	1,294	
	N	tf	9,479	
	S	tf	2,068	
Amount of reinforcing bars	Covering	cm	1.5	1.5
	d	cm	23.5	23.5
	As	cm^2	5.240	2.620
Generated unit stress	σ_c	kgf/cm^2	25.4	25.4
	σ_s	kgf/cm^2	366.0	732.0
	τ	kgf/cm^2	0.88	0.88
Allowable unit stress	σ_c	kgf/cm^2	77.0	
	σ_s	kgf/cm^2	1,400.0	
	τ	kgf/cm^2	4.25	

In either case, allowable unit stress exceeds unit stress to be predicted to generate. Therefore, it is judged possible to reuse the existing circular concrete section, provided that the concrete section is sound.

(c) Study on possibility to reuse the directly buried section of the existing steel pipe

The wall thickness of steel pipe which was initially 8 mm was revealed to be reduced to 5.5 mm ~ 7.4 mm as a result of investigation of the wall thickness of the pipe in May 1994.

Therefore, it is understood that the thickness was corroded by as much as 2.5 mm ~ 0.6 mm for thirty-five (35) years.

Meanwhile, vehicles will pass on the road above the pipe during construction and operation of the power plant. Where a vehicle is assumed to generate a load of 1 ton/m^2, then the wall thickness of ϕ 2,200 mm pipe should be 22 mm, taking into consideration a 2 mm of allowance for corrosion during future (30) year.

Therefore, the pipe strength is substantially insufficient under the present situations (Actual stress: 4,230 kgf/cm^2>Allowable stress: 1,300 kgf/cm^2)

The wall thickness of the existing pipe is too small to reinforce the pipe on its internal surface and it will also be impossible to reinforce the pipe on its external surface, because of miscellaneous piping foundations located on the aboveground section.
Therefore, the pipe should be reinforced by means of a countermeasure as described below:

1) Range of aboveground section where miscellaneous piping and foundations are located (Red section in Figure 5-4-1-1)

   A new ϕ 1,800 mm steel pipe with a thickness of 18 mm should be inserted inside the existing ϕ 2,200 mm steel pipe and mortar be injected into the surrounding section.

   Meanwhile, a new steel should be of a construction to bear all the load while allowing the existing steel pipe to be corroded in future.

2) Range of aboveground section where there is no structure (Yellow section in Figure 5-4-1-1)

   A new waterway will be constructed after dismantling the existing steel pipeline. Meanwhile, the ϕ 2,200 mm steel pipe with a plate thickness of 8 mm available in Bulgaria can be adopted, and be of a construction of lining the outside of the steel pipe with concrete.

   Moreover, the concrete lining (thickness) will be of such a construction as to withstand a load of 7 t/m^2, taking into consideration the load of equipment installation machinery and equipment during construction of the power plant.

(d) Study on section to be newly installed (Blue section in Figure 5-4-1-1)

The section to be newly installed will be of a construction of ϕ 2,200 mm x t 8 mm steel pipe lined with concrete.

(3) Discharge Waterway

(a) Present situations

The existing discharge waterway is of a concrete box culvert construction and consists of two lines, each being about 400 m long.

(b) Study on the existing concrete box culvert

It is concluded that the existing concrete box culvert section can be used, on the assumption that the existing box culvert concrete would be sound for the time being, although the soundness of the section has not been diagnosed for more than thirty-five (35) years after installation and the soundness of concrete is not clear.

(c) Study of circulating water culvert (pipeline) to be newly installed (Green section in Figure 5-4-1-1)

All the circulating water culvert/pipeline section from the main powerhouse through to the concrete box culvert should be newly installed, and its construction be the same as the intake pipe.

(d) Box culvert to be newly installed (Orange color section in Figure 5-4-1-1)

One line of concrete box culvert with inside dimensions of 2.20 m x 2.85 m similar to those of the existing discharge waterway should be installed newly from the circulating water terminal point section through to the existing box culvert.

(4) Matters to be studied for project implementation

The soundness of both circular concrete culvert in the existing intake waterway and box concrete culvert in the discharge waterway have not been studied.

Assuming, however, that concrete only would be sound, it is judged that they are sound, for the time being.

In actual implementation, it is suggested that their soundness shall be judged after study on the soundness of concrete.

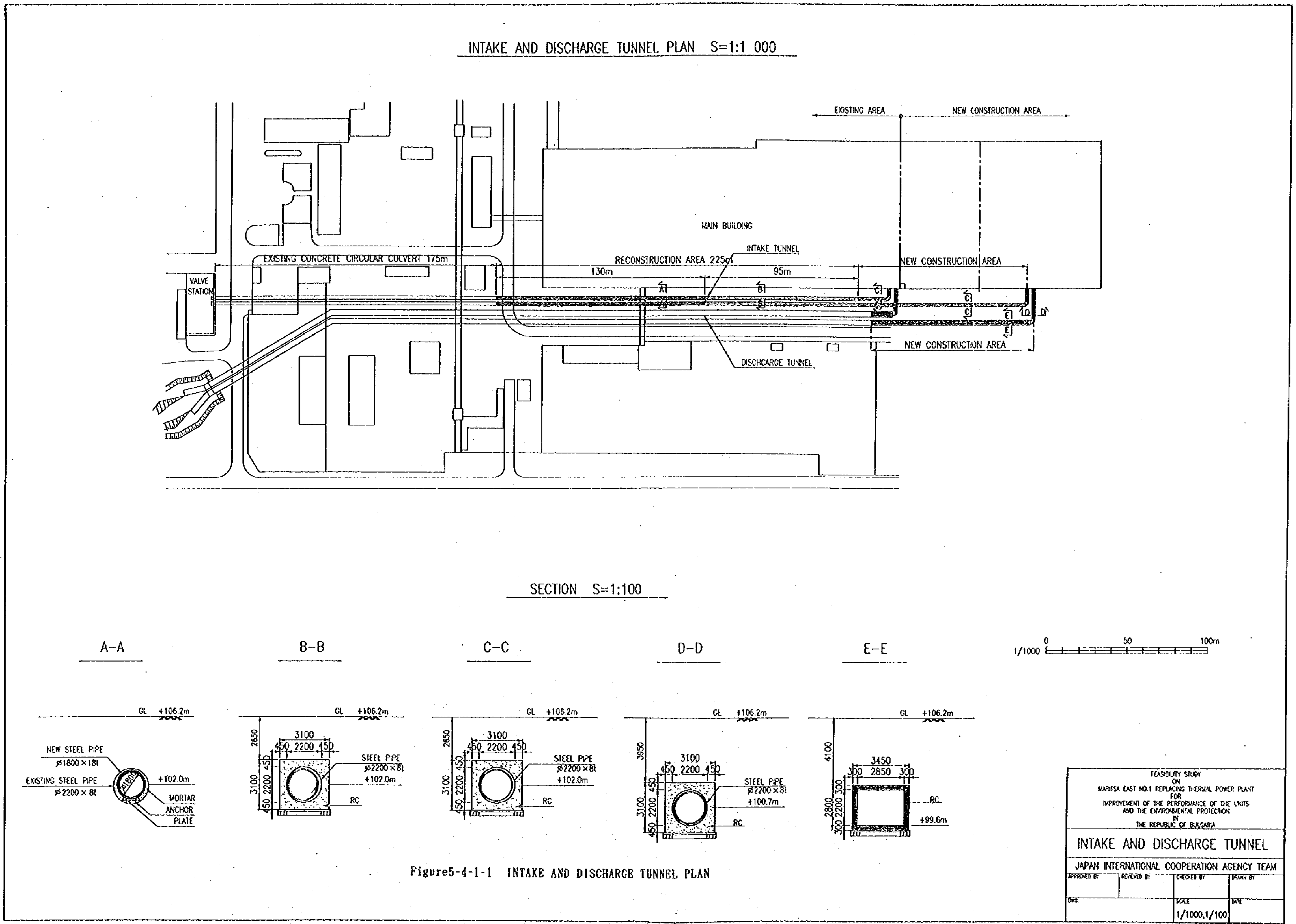


Figure5-4-1-1 INTAKE AND DISCHARGE TUNNEL PLAN

5.4.2 Turbine Hall

The existing buildings, if possible even partly, are planned to be used for this replacing project. Main equipment for the replacing project will be installed at the area for Units 5 and 6 within the existing turbine hall. However, the space for this replacing project is judged to be insufficient due to difficulty in equipment arrangement between the turbine hall and the stack. As such, it is judged difficult to use the entire area of the Units 5 and 6 existing turbine hall. Therefore, a part of the existing turbine hall will be used and a supplementary new turbine hall will be built beside the existing structure.

The plan f the turbine hall and the surrounding structures is complicated due to equipment layout in both the existing turbine hall and a new one. Therefore, some points should be considered at the time of planning and detailed design of the turbine hall.
The results of diagnosis of durability of the existing turbine hall, shown in Table 5-4-1, should be checked in detail.

As use of the existing turbine hall has economical merits, optimal building planning is necessary in order to make full use of these merits.

5.4.3 Stack (Chimney)

It is judged that the existing stack (H=180m) can not be reused due to difficulty in equipment arrangement for this replacing project. Therefore, a new stack should be planned to be built, and the existing stack removed.

5.4.4 Mechanical Facilities

Among the existing mechanical facilities, the following facilities will be reused.

(1) River water transfer pumps and pipings
(2) Overhead travelling cranes (in the turbine building)
(3) Crane for maintenance (in the circulating water pump house)
(4) Hot water pipings for the district heating
(5) Fire protection equipment

Table 5-4-1 Results of diagnosis of durability

Check Items	Evaluation by items			Remarks
	Line A	Line Б	Line B	
Cracking	1	1	1	Only cracks having a size of less than 0.3mm, but which do not extend through the entire column, beam and floor, were observed.
Water leakage	1	1	1	No water leakage from the floors (ceiling) was observed.
Deterioration of surface	1	1	1	No separation, exposure of reinforcement, floating and expansion due to corrosion of reinforcement were observed.
Neutralization of concrete	0.55	0.43	0.7	Neutralization was found near main bar of column by sampling core test in line A and Б.
Corrosion of steels in concrete	1	1	1	Mill scale was still observed for reinforcement of the column, which was chipped out for inspection.
Chemical attack on concrete	1	1	1	No surface damage of concrete and sampling core were found.
Compressive strength of concrete	1	1	1	The strength was more than the design strength by sampling core test.
Unevenness of building surface	1	1	1	No unevenness was found from measurement, and no damage was observed.
Deflection	1	1	1	Deflection of slab, beam and upper steel structure was less than the tolerance as observed from measurement.
Deterioration coefficient	0.97	0.96	0.98	This figure shows the ratio of deterioration against 1 (sound condition).
Standard remaining service life (year)	62	62	62	This figure is calculated from the service life as a depreciable asset of 84 years; 34 years have elapsed.
Service life index	75	74	76	This figure shows the ratio of the modified standard remaining service life due to deterioration against the service life as a depreciable asset.
Rank of durability evaluation	B			The rank of evaluation is from A to D. Rank A is sound. Rank D requires immediate countermeasures.
Total evaluation	Neutralization of concrete is advanced. However, other items show sound conditions. This building is ranked B, and in the future, will probably proceed to rank C or D. Therefore, continuous checks are necessary.			

CHAPTER 6. CONCEPTUAL DESIGN

CHAPTER 6 CONCEPTUAL DESIGN

6.1 Design Specifications

Basic general specifications for plant design are as follows.

(1) Rated output: Electric output 230MW x 2 units

(2) Hot water for local heating: 25Gcal/h

This equipment is provided on both units, but one of them is used for actually supplying hot water. At this time, the electric output of a machine supplying hot water decreases depending on supplied calorific value.

(3) Steam condition

(a)	Main steam flow	740 t/h/unit (MCR)	
(b)	Main steam pressure:	169 kg/cm^{2}g (2,400 psig/in^2)	(at turbine inlet)
(c)	Main steam temperature:	538°C (1,000°F)	(at turbine inlet)
(d)	Reheated steam temperature:	538°C (1,000°F)	(at turbine inlet)

(4) Lignite and ash properties: Shown in Table 6-1-1

(5) Limestone property: Shown in Table 6-1-2

(6) Heavy oil property: Shown in Table 6-1-3

(7) Yearly plant availability: 70%

(8) Minimum load: 40%

(9) Restriction standard for flue gas emission:

(a)	SO_2:	More than 90% of desulfurization efficiency
(b)	NOx:	Less than 600mg/m^{3}N (292ppm)
(c)	Dust:	Less than 100mg/m^{3}N
(d)	CO:	Less than 250mg/m^{3}N (200ppm)

(10) Waste water standard: Class 3 of the Bulgarian standard "Index and standard to be applied to evaluation of quality of surface flow water" shall be observed.

(11) Overload:

(a)	Boiler MCR:	Less than 103% ECR
(b)	Turbine TMF:	Less than 105% rated output
(c)	Generator:	Less than 105% rated output

(12) Storage amounts of lignite and limestone: For 23 days

(13) Temperature: -20° to 40°C

(14) Wind speed: 38 kg/m^2

(15) Seismic coefficient: 0.08G

Table 6-1-1 Design Lignite Properties

Coal classification			A Max
Ash	(air-dried base)	%	45.00
Moisture	(as received)	%	49.00
Ash	(as received)	%	22.95
Carbon	(as received)	%	18.85
Hydrogen	(as received)	%	1.42
Oxygen	(as received)	%	5.05
Nitrogen	(as received)	%	0.30
Combustible sulphur	(as received)	%	3.20
Volatiles from mineral substance	(as received)	%	2.19
Calorific value (LHV)	kcal/kg kJ/kg		1,315 5,510
Volatiles		%	60 - 64
Hygroscopic moisture		%	11
Milling efficiency	per K per for guaranteed coal		0.83 - 1.22 K=1.1
Ash analysis	SiO_2	%	35 - 50
	Al_2O_3	%	16 - 32
	Fe_2O_3	%	7 - 20
	MgO	%	1.5 - 3.5
	CaO	%	2.5 - 5.0
	SO_3	%	2.5 - 15
Ash fusion temperature			
A. In oxidizing environment (by Leits) for Analysis 1,2,3			
Deformation point		℃	1,210 - 1,300
Melting point		℃	1,260 - 1,300
Running point		℃	1,280 - 1,300
B. In semi-reduction environment (by Bunte-Baum) for Analysis 4			
Deformation point		℃	1,050 - 1,150
Melting point		℃	1,150 - 1,300
Running point		℃	1,200 - 1,400
Density	gr/cub. cm		1.5 - 1.9
Bulk weight	kg/cub. cm		700 - 1,000

Table 6-1-2 Design Limestone Properties

Original limestone analysis (air dried base)		Ca (%)	38.8
		Mg (%)	0.1
		C (%)	11.94
		S (%)	0.004
Fraction analysis between 0.125 - 0.250 mm (air dried base)		Ca (%)	39
		Mg (%)	0.1
		C (%)	11.94
		S (%)	0.003
Limestone specification	Grade	Reactive Index RI (mol/mol)	Absorption Capacity CI (Limestone gs/kg)
	excellent	< 2.5	120 <
	good	2.5 - 3.0	100 - 120
	medium	3.0 - 4.0	80 - 100
	low	4.0 - 5.0	60 - 80
	bad	5.0 <	< 60

Table 6-1-3 Heavy Oil Properties

Item		Bulgarian Standard	Acceptable Properties
Calorific value [HHV]	MJ/kg Kcal/kg	39.8 9,506	39.88 9,525
Kinematics viscosity	mm^2/s	115	—
Density	g/cm^3	1.015	0.968
Ash content	Weight %	0.15	0.068
Sulfur content	Weight %	3.5	2.99
Moisture	Volume %	1.0	—
Impurities	Weight %	0.5	—
Flash point	℃	110 or more	120 or more
Pour point	℃	25 or less	7 or less

6.2 Planned Performance

Equipment and performance planned according to the design specifications are shown below.

(1) Type of main equipment

(a)	Boiler:	Indoor, circulating fluidized bed, single drum, radiant reheat type
(b)	Dust collector:	Electrostatic type
(c)	Turbine:	Tandem, 2-wheel chamber, double-flow exhaust type
(d)	Generator:	Hydrogen cooling, lateral rotating field, explosion proof, three-phase AC synchronous type

(2) Plant performance

Table 6-2-1 shows plant efficiency, utilities, gas properties, etc.

Table 6-2-1 Planned Performance

(per 1unit)

1. Boiler type		C-FBC
2. Coal		Ash MAX
3. Plant efficiency (wet low calorie base)	%	36.5
Boiler efficiency	%	87.6
Turbine efficiency	%	45.0
Auxiliary power consumption	%	7.0
Plant loss	%	0.3
4. Plant efficiency (wet high calorie base)	%	28.5
Boiler efficiency	%	68.3
Turbine efficiency	%	45.0
Auxiliary power consumption	%	7.0
Plant loss	%	0.3
5. Coal consumption (wet base)	T/H	412
	T/D	9,888
(plant annual utilization = 70%)	$\times 10^3$T/Y	2,526
6. Limestone consumption	T/H	85
	T/D	2,040
(plant annual utilization = 70%)	$\times 10^3$T/Y	521
Surplus rate	—	2.0
7. Make up water	T/H	73
Plant using	T/H	73
FGD using	T/H	—
	T/D	1,752
(plant annual utilization = 70%)	$\times 10^3$T/Y	448
8. Ash disposal quantity	T/H	225
	T/D	5,400
(plant annual utilization = 70%)	$\times 10^3$T/Y	1,380
9. By-product gypsum	T/H	—
	T/D	—
(plant annual utilization = 70%)	$\times 10^3$T/Y	—
10. Boiler outlet flue gas		
Wet base	$\times 10^3 m^3$N/H	1,294
Dry base	$\times 10^3 m^3$N/H	978
Gas temperature	℃	165
11. Flue gas properties at stack outlet		
Wet base	$\times 10^3 m^3$N/H	1,297
Dry base	$\times 10^3 m^3$N/H	981
Gas temperature	℃	170
SO_2	mg/m^3N	2,687
NOx	mg/m^3N	<600
Dust	mg/m^3N	<100
CO	mg/m^3N	<250

6.3 Layout

Figure 6-3-1 - 2 show layout of the power plant.

(1) Turbine buildings for units R1 and R2 of a replacing plant will be extended 153m in a northern direction from a point 58m north of the turbine building for remaining unit nos. 1~4 in use.

(2) A new selfstanding 1-tower 2-flow type stack of 180 m high will be installed at the center of units R1 and R2 of a replacing plant.

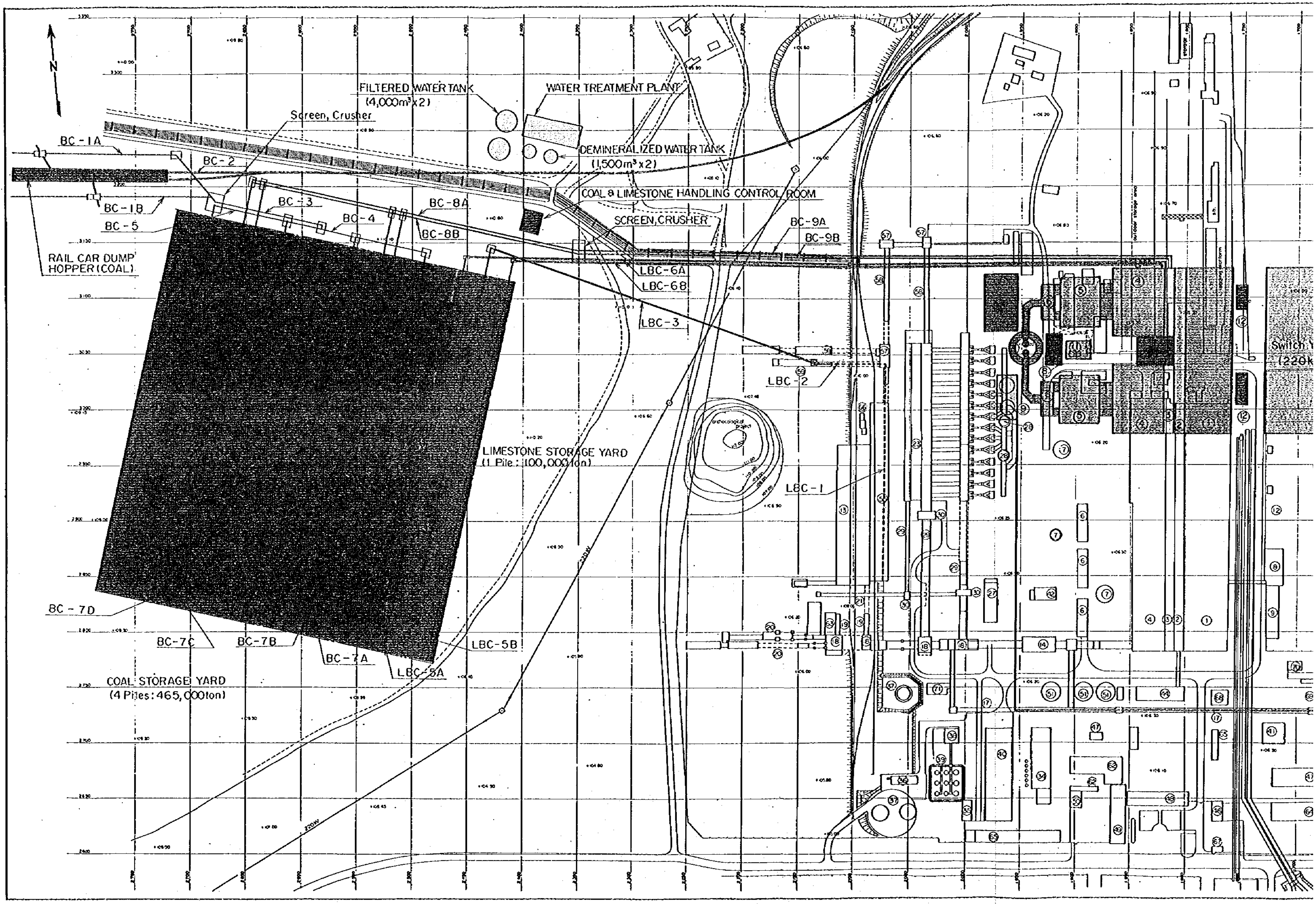
(3) Ash treatment unit will be allocated between electrostatic precipitators for units R1 and R2 of a replacing plant. Ash is transferred to railway freights to transport to outside through a storage tank.

(4) A waste water treatment equipment will be allocated north west of a new stack.

(5) A station water treatment equipment will be allocated north of a reclaimed ash disposal site.

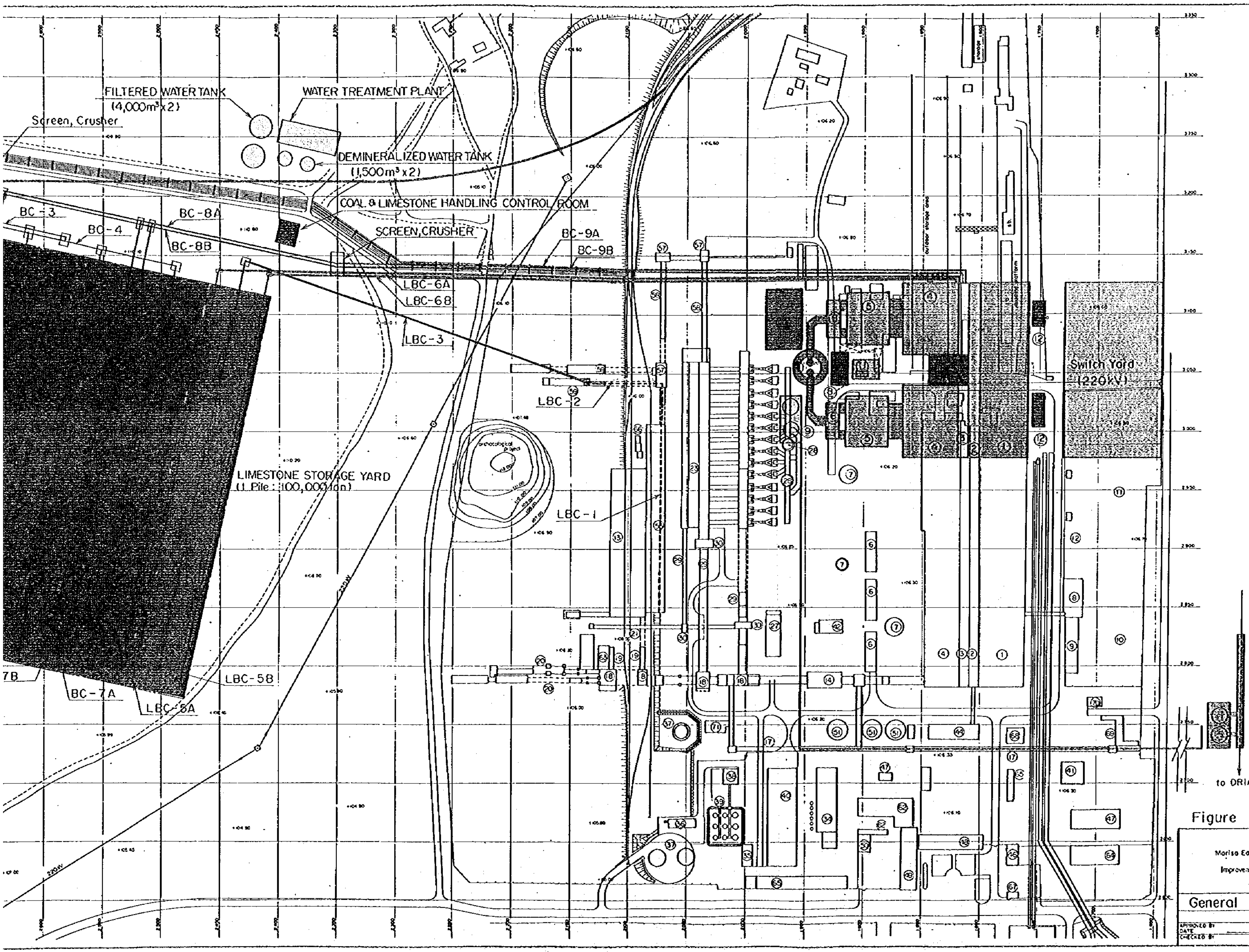
(6) A coal storage yard will be allocated at the ash disposal site.

(7) A limestone storage place will be allocated at the reclaimed ash disposal site.



N
FILTERED WATER TANK
(4,000m³x2)
WATER TREATMENT PLANT
Screen, Crusher
BC-1A
BC-2
DEMINERALIZED WATER TANK
(1,500m³x2)
COAL & LIMESTONE HANDLING CONTROL ROOM
BC-1B
BC-3
BC-8A
BC-5
BC-4
BC-8B
SCREEN, CRUSHER
BC-9A
BC-9B
RAIL CAR DUMP
HOPPER (COAL)
LBC-6A
LBC-6B
LBC-3
LBC-2
LIMESTONE STORAGE YARD
(1 Pile: 100,000 ton)
LBC-1
BC-7D
BC-7C
BC-7B
BC-7A
LBC-5B
LBC-5A
COAL STORAGE YARD
(4 Piles: 465,000ton)
220W


WATER TREATMENT PLANT
DEMINERALIZED WATER TANK
SCREEN CRUSHER
BC-2
BC-3
BC-4
BC-6A
BC-6B
BC-9B
LBC-6A
LBC-6B
LBC-3
BC-6D
STOCK PILE (COAL)
BC-6C
STOCK PILE (COAL)
BC-6B
STOCK PILE (COAL)
BC-6A
STOCK PILE (COAL)
LBC-4
STOCK PILE (LIMESTONE)
BC-7C
BC-7B
BC-7A
LBC-6A
Switch
(220



No	Description
	I. MAIN BUILDING
1	Turbine hall
2	Deorator section
3	Bunker section
4	Boiler section
5	Outdoor for flue gas fans
6	Switchgear for electric precipitators
7	Stack
	II. ELECTROTECHNICAL STRUCTURES
8	Covered unloading
9	Indoor switchyard
10	Switchyard - 110kV
11	Switchyard - 220kV
12	Transformer site
	III. STRUCTURES OF COAL SUPPLY SYSTEM
13	Electric control room
14	Coal crusher building
15	Coal transport trestles - 1st uplift
16	Coal transport trestles - 2nd uplift
17	Trestles from briquette plant
18	Transfer stations No 1, 2, 3, 4
19	Coal supply galleries
20	Trestles and galleries to outdoor coal storage
21	Trestle for dry fuel supply
22	Outdoor coal storage
	IV. STRUCTURES OF COAL DRYING PLANT
23	Drying plant
24	Outdoor site under the drums
25	Building for cyclones
26	Outdoor site for funnel suckers
27	Compressor station to the drying plant
28	Stack
29	Trestles for the coal conveyers from drying plant
30	Transfer stations No 5, 6, 7
	V. STRUCTURES FOR SERVICE WATER SUPPLY
31	Bank pump station
32	Switching chamber
33	Open air outgoing channel
	VI. SERVICE BUILDINGS AND STRUCTURES
34	Water treatment plant
35	Turnery workshop to U.A. Building
36	Pump station for heavy fuel oil
37	Heavy fuel oil tanks
38	Oil facility
39	Outdoor oil storage
40	Unified auxiliary building
41	Open air hydrogen tanks
42	Dredger - pump station
43	Compressed - air station
	VII. SECOND COAL SUPPLY TO DRYING PLANT
56	Covered unloading - extension
57	Transfer stations No 8, 9, 10
58	Coal transport trestles
59	Trestles and galleries to outdoor storage
60	Outdoor coal storage 3
	VIII. AUXILIARY BUILDINGS AND STRUCTURES
44	Office building
45	Walkway
46	Security building and health centre
47	Amenities building
48	Administrative building
49	Garage
50	Carwash
51	Condensate tanks
52	Repair shop
53	Acetylene station
54	Carbide storage
55	Oxygen station
61	Accumulator battery
62	Bathroom
63	Garage for bulldozers
64	Restaurant
65	Covered storage
66	Building for
67	Bus stop
68	Boiler station for heating supply
69	Anti-fire defence
70	Garage for electric trucks
71	Tools workshop

Replacing Plant

1	Turbine hall
2	Deaerator section
3	Bunker section
4	Boiler section
5	Electrostatics precipitator
6	IDF (Induced Draft Fan)
7	Stack
8	Fly ash transmitter tank
9	Fly ash silo
10	Central control room
11	Ash handling control room
12	Transformer yard
13	Waste Water Treatment Yard

Figure 6-3-1

The Feasibility Study
on
Marisa East No.1 Replacing Thermal Power Plant
for
Improvement of The Performance of The Units
and
The Environmental Protection

General Layout SCALE:

JICA TEAM

APPROVED BY DATE	REVIEWED BY
CHECKED BY	DRAWN BY

Switch Yard
(220kV)
BC-6B
STOCK PILE (COAL)
BC-6A
STOCK PILE (COAL)
LBC-4
STOCK PILE (LIMESTONE)
General Layout

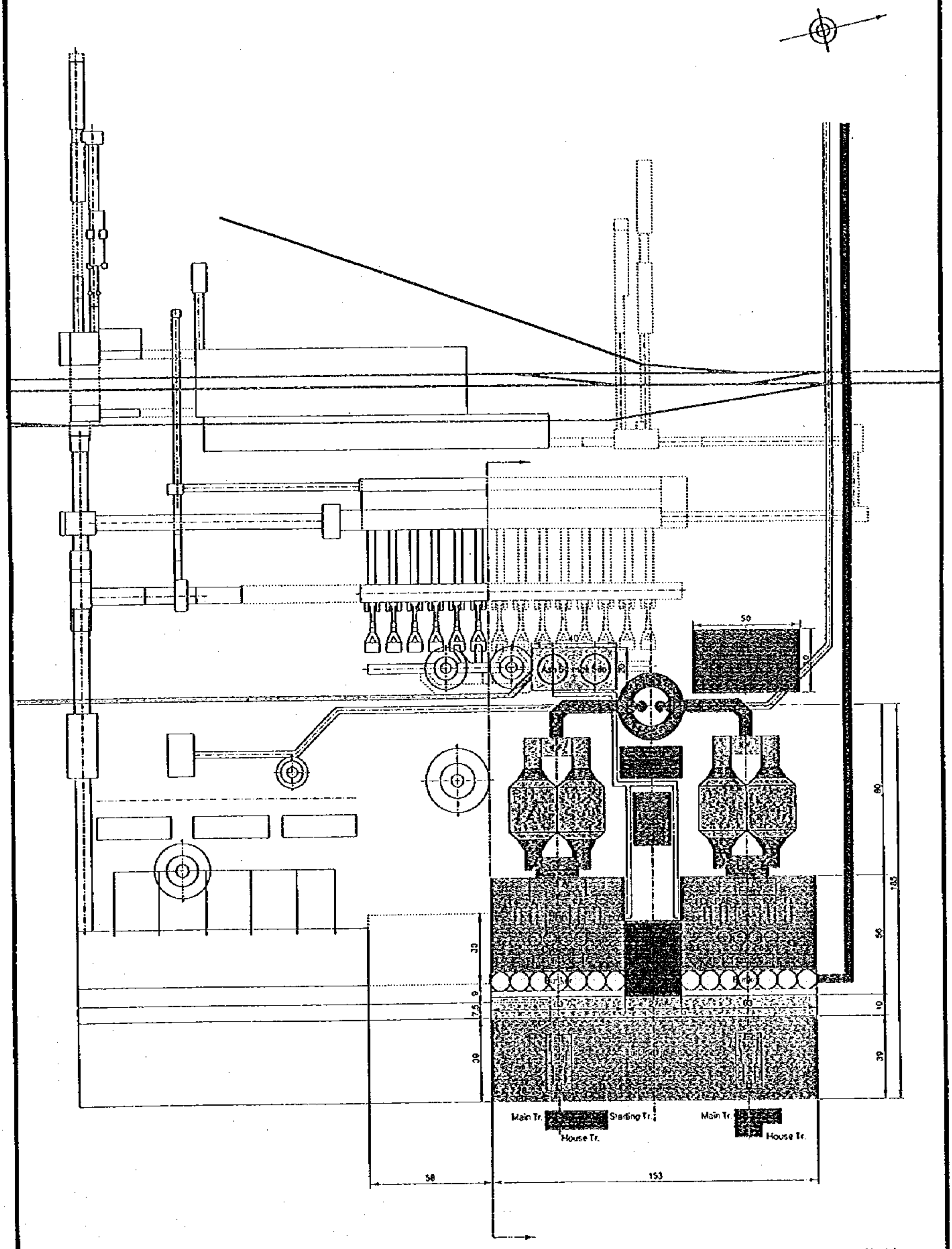


Figure 6-3-2 CFBC(230MW) Layout

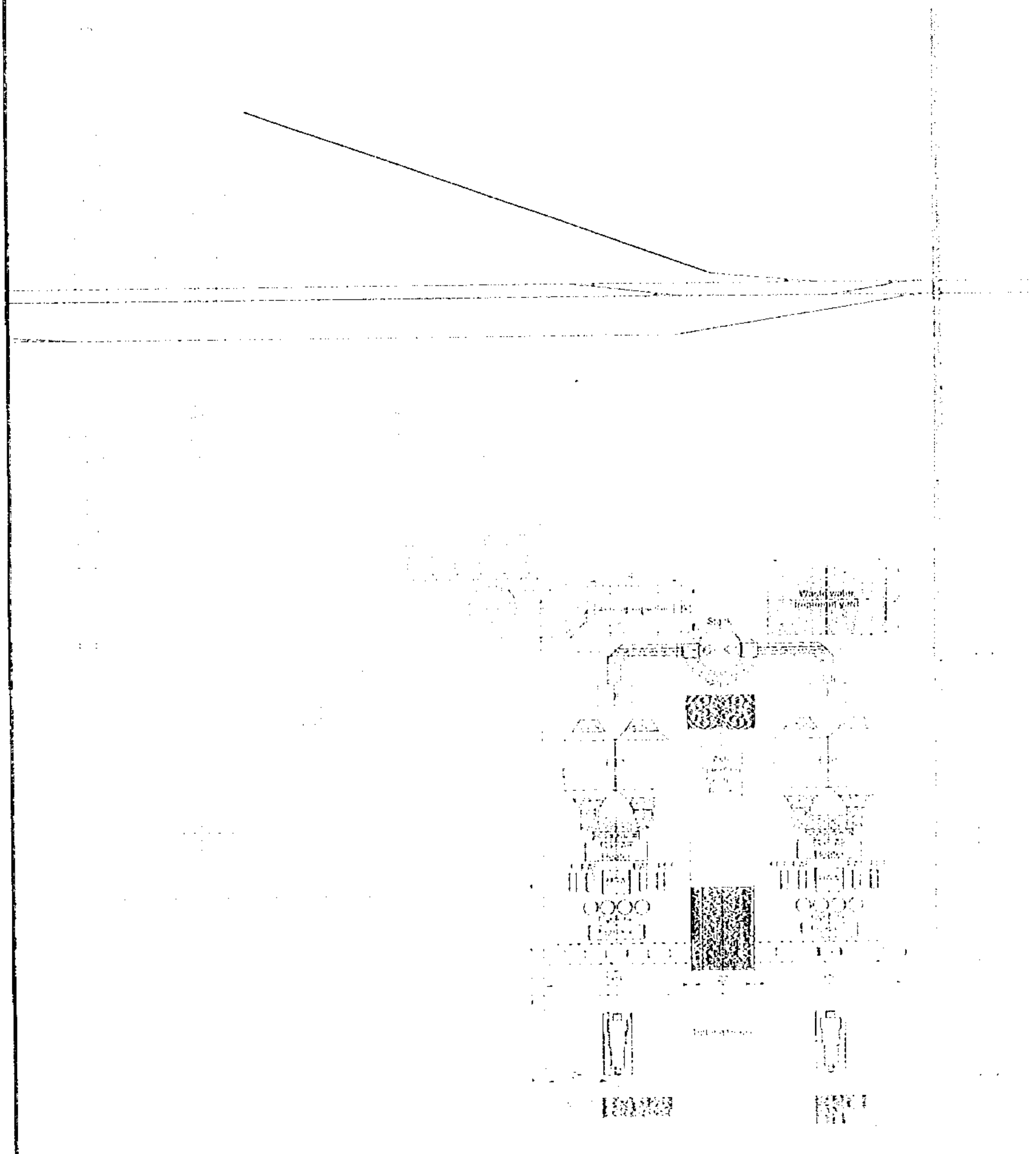


Figure 6-3-2 CFBC(230MW) Layout

6.4 Material Balance and Schematic Diagram on Boiler

Figure 6-4-1 shows material balance and schematic diagram on the Boiler site. The brief process of each system is as described below.

(1) Lignite supplying system

Fuel lignite is crushed to less than 40mm and supplied to seven coal storage bunkers hold a capacity of a 6- hour operation at MCR by six bunkers in the boiler building continuously for 24 hours. Then lignite is further crushed to less than 12mm by means of coal crushers and discharged through seven coal feed bunkers to 14 coal feeders.

Then, the crushed lignite drops by gravity into the furnace bottom .

(2) Limestone supplying system

Limestone, desulfurizing agent, is crushed to less than 50mm is supplied to a limestone bunker's in the boiler building. Then limestone is crushed to less than 3mm by limestone crushers and discharged to lignite feeding pipe by air through the limestone feed bunkers, and then finally supplied to the furnace bottom together with lignite.

(3) Air feed system

Combustion air which is intaked from indoors of boiler building is branched after its pressure is raised by FDF. One of the pressurized air is further raised by PAF and warmed by GAH, and then supplied to the inside of the furnace from a window box on the bottom of the furnace. The other is warmed by GAH and supplied to the upper furnace for combustion and NOx control.

(4) Gas system

Combustion gas from the furnace is introduced into the cyclone and separated from bed material accompanied by combustion gas. Combustion gas is lod to heat recovery area to undergo heat exchange and is introduced to GAH to heat up air. After that, flue gas is removed the dust by means of an electrostatic precipitator and is discharged from a stack through the IDF. On the other hand, the separated bed material is returned to the furnace bottom through a recirculating line, which contributes to higher combustion efficiency and for furnace temperature control.

(5) Ash treatment system

Bed material is pulled out of furnace bottom is cooled by means of a bed material cooler and transferred to an ash transit tank by vacuum. Combustion ash and generated gypsum discharged from economiser hoppers, GAH hoppers and electrostatic precipitator hoppers are transferred to the ash transit tank by vacuum and then carried to an outside ash disposal site through an ash storage silo together with bed material.

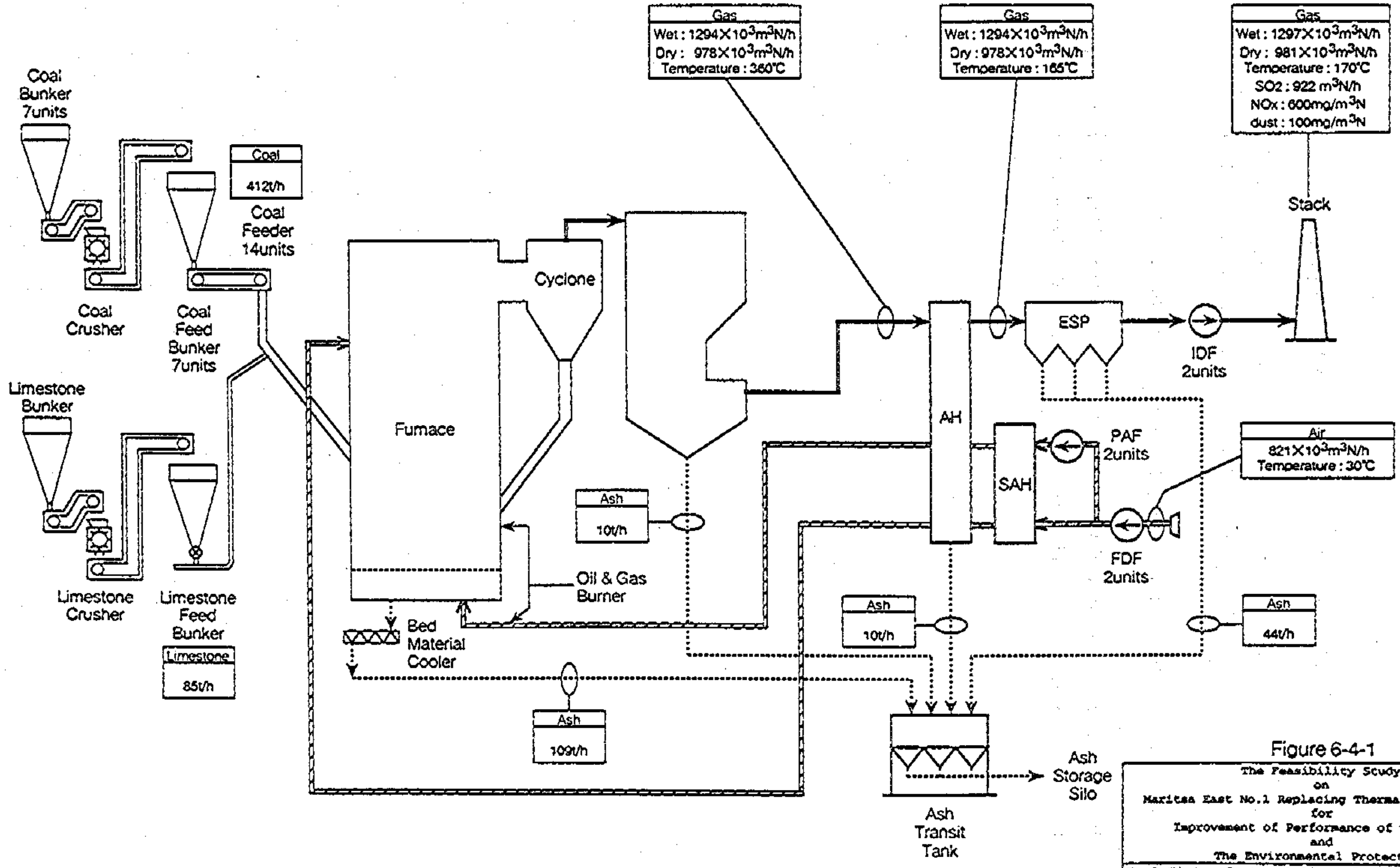


Figure 6-4-1

The Feasibility Study on Maritsa East No.1 Replacing Thermal Power Plant for Improvement of Performance of The Units and The Environmental Protection	
Fuel Firing System & Air & Gas Draft System Material Balance	SCALE
JICA TEAM	
APPROVED BY DATE	REVIEWED BY
CHECKED BY	DRAWN BY

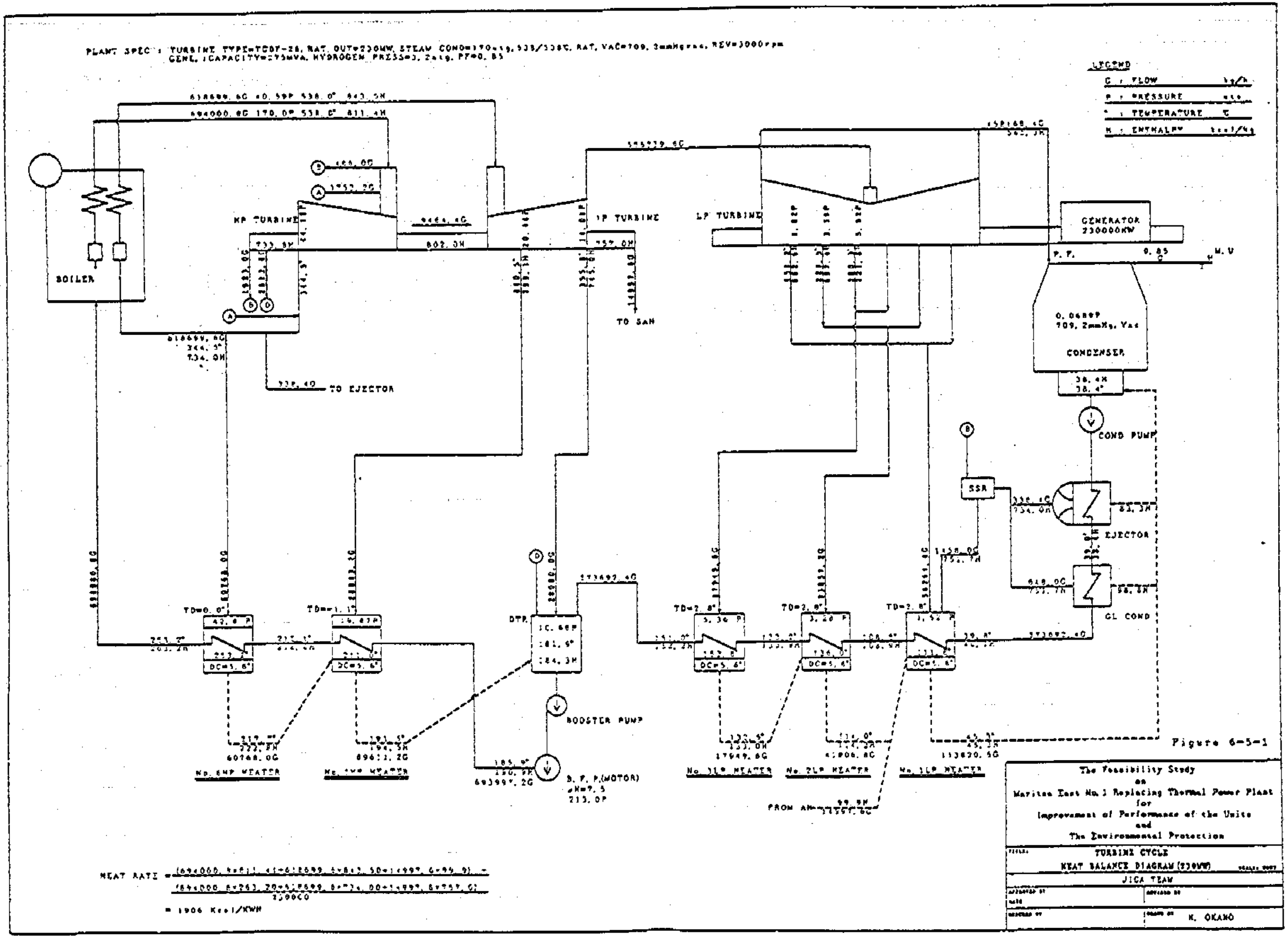
6.5 Turbine Cycle Heat Rate

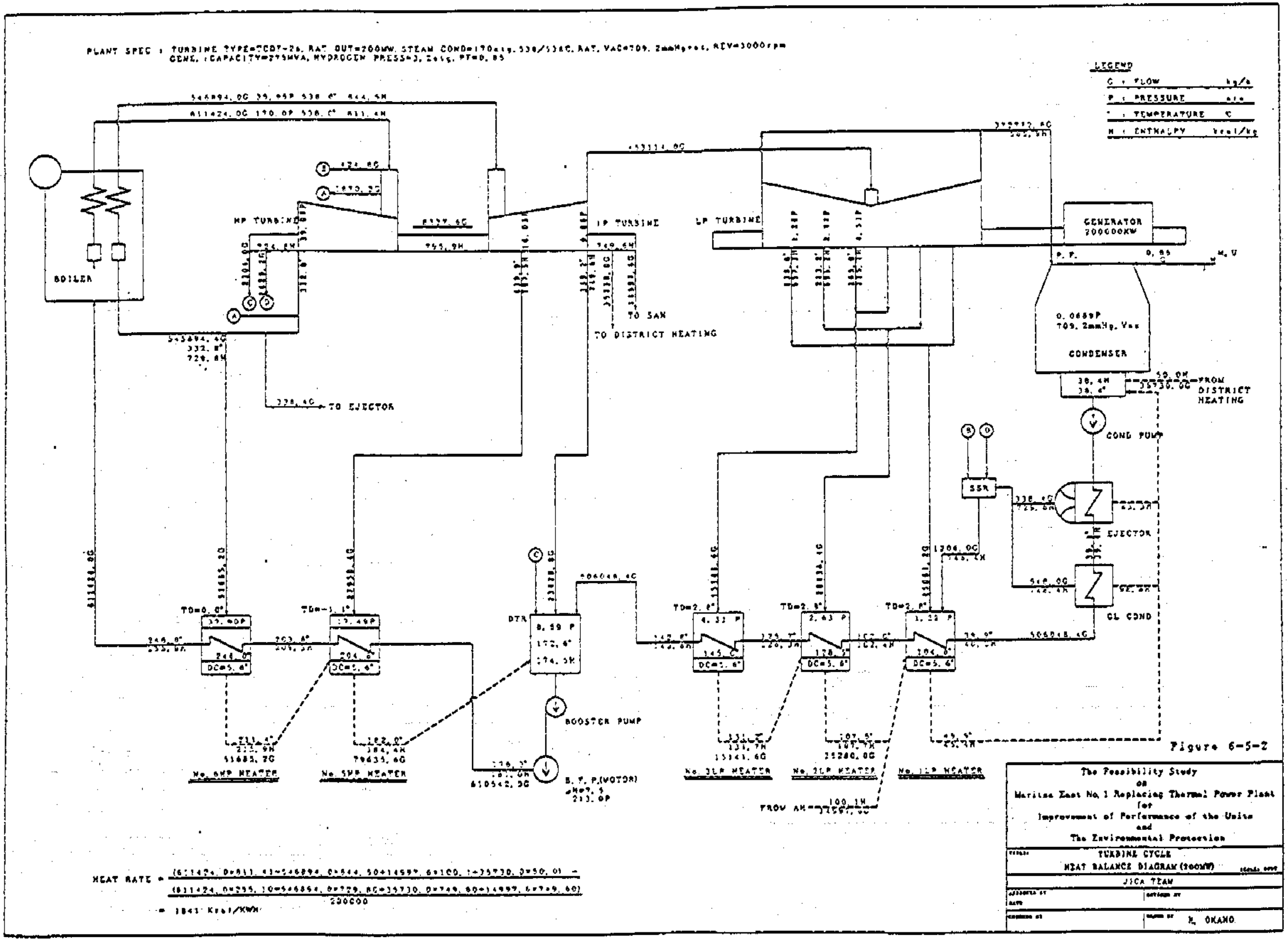
6.5.1 In Case of 230MW Rated Output (Without the District Heating)

When the rated output is 230MW, turbine cycle heat rate is 1,906 kcal/kWh (45.12%). Figure 6-5-1 shows "Turbine Cycle Heat Balance Diagram" at 230MW rated load.

6.5.2 In Case of 200MW Rated Output (With the District Heating)

When the rated output is 200MW, turbine cycle heat rate is 1,841 kcal/kWh (46.7%). Figure 6-5-2 shows "Turbine Cycle Heat Balance Diagram" at 200MW rated load.


LEGEND
G : FLOW
P : PRESSURE
T : TEMPERATURE
H : ENTHALPY
BOILER
HP TURBINE
IP TURBINE
LP TURBINE
GENERATOR 230000KW
CONDENSER
TO EJECTOR
TO SAH
COND PUMP
SSR
EJECTOR
GL COND
DTR
BOOSTER PUMP
B. F. P.(MOTOR)
No. 6HP HEATER
No. 5HP HEATER
No. 3LP HEATER
No. 2LP HEATER
No. 1LP HEATER
FROM AH
= 1906 Kcal/KWH
The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of Performance of the Units
and
The Environmental Protection
TURBINE CYCLE
HEAT BALANCE DIAGRAM (230MW)
JICA TEAM
K. OKANO
Figure 6-5-1


LEGEND
BOILER
HP TURBINE
IP TURBINE
LP TURBINE
GENERATOR 200000KW
CONDENSER
TO EJECTOR
TO SAN
TO DISTRICT HEATING
FROM DISTRICT HEATING
COND PUMP
EJECTOR
GL COND
SSR
DTR
BOOSTER PUMP
B. F. P.(MOTOR)
No. 6HP HEATER
No. 5HP HEATER
No. 3LP HEATER
No. 2LP HEATER
No. 1LP HEATER
FROM AH
Figure 6-5-2
The Feasibility Study
on
Maritsa East No. 1 Replacing Thermal Power Plant
for
Improvement of Performance of the Units
and
The Environmental Protection
TURBINE CYCLE
HEAT BALANCE DIAGRAM (200MW)
JICA TEAM
K. OKANO

6.6 Boiler Equipment

6.6.1 Boiler Design Condition

(1) Unit output : 230MW (ECR)

(2) Boiler type : Circulating fluidized bed combustion boiler (C-FBC)

(3) Steam conditions at MCR

(a)	Main steam flow	:	740 t/h	
(b)	Main steam pressure	:	173 kg/cm^{2}g	(at boiler exit outlet)
(c)	Main steam temperature	:	541°C	(at boiler exit outlet)
(d)	Reheated steam temperature	:	541°C	(at boiler exit outlet)

(4) Economiser inlet water temperature (at MCR) : 252°C

(5) Draught system : Balanced

(6) Restrictions of emission (stack exit, on the basis of O_2=6%)

(a)	SO_2	:	More than 90% of desulfurization efficiency
(b)	NOx	:	Less than 600mg/m^{3}N (292ppm)
(c)	Dust	:	Less than 100mg/m^{3}N
(d)	CO	:	Less than 250mg/m^{3}N (200ppm)

(7) Boiler side view : Shown in Figure 6-6-1

6.6.2 Boiler Equipment Specification

Specifications for 1 plant design are as follows.

(1) Boiler Equipment

(a) Boiler pressure parts

1) Furnace

Type : Natural circulation, water cooled, welded membrane construction

2) Drum

Type	:	Single drum provided with steam separators, welded construction

3) Cyclone

Type	:	Centrifugal separation
Catching efficiency	:	More than 99.5%

4) Super heater

Type	:	Convection and if any radiant

5) Reheater

Type	:	Convection

(b) Air preheater (GAH)

1) Specification

Type	:	Regenerative, bi-sector
Quantity	:	1 unit

2) Temperature conditions

GAH outlet gas temperature	:	165°C (MCR)
GAH inlet air temperature	:	65°C (MCR)

(c) Steam air preheater (SAH)

1) Specification

Type	:	Finned tube
Quantity	:	1 unit

2) Temperature conditions

SAH outlet gas temperature	:	65°C (MCR)
SAH inlet air temperature	:	40°C (MCR)

(d) Soot blower

Type	:	Automatic or manual operated, steam injection type

(2) Coal and limestone supplying equipment

(a) Coal supplying equipment

1) Coal storage bunker

Type	:	Steel plate lined with antifriction material
Quantity	:	7 units (one for spare)
Capacity	:	For 6 hour operation at MCR/6 bunkers

2) Coal crusher

Type	:	Hammer
Quantity	:	7 (one for spare)
Capacity	:	70 t/h/crusher

3) Coal feed bunker

Type	:	Steel plate lined with antifriction material
Quantity	:	7 units (one for spare)
Capacity	:	For 2 hour operation at MCR/6 bunkers

4) Coal feeder

Type	:	Enclosed belt, gravimetric
Quantity	:	14 units
Capacity	:	50 t/h/feeder

5) Coal chute

Type	:	Chute provided with air spreaders
Quantity	:	14

(b) Limestone transportation equipment

1) Limestone storage bunker

Type	:	Steel plate
Capacity	:	6 hour operation at MCR

2) Limestone crusher

Type	:	Hammer type
Capacity	:	90 t/h

3) Limestone feed bunker

Type	:	Steel plate

4) Limestone rotary valve

Type	:	Rotary type
Capacity	:	90 t/h

(3) Heavy oil burning equipment

(a) Heavy oil burner

Type	:	Lance, steam atomized
Capacity	:	30% MCR

(b) Start up burner

Type	:	Electric ignited duct burner
Capacity	:	15% MCR

(4) Draft fan

(a) Forced draft fan (FDF)

Type	:	Centrifugal
Quantity	:	2 units

(b) Primary air fan (PAF)

Type	:	Centrifugal
Quantity	:	2 units

(c) Induced draft fan (IDF)

Type	:	Centrifugal fan
Quantity	:	2 units

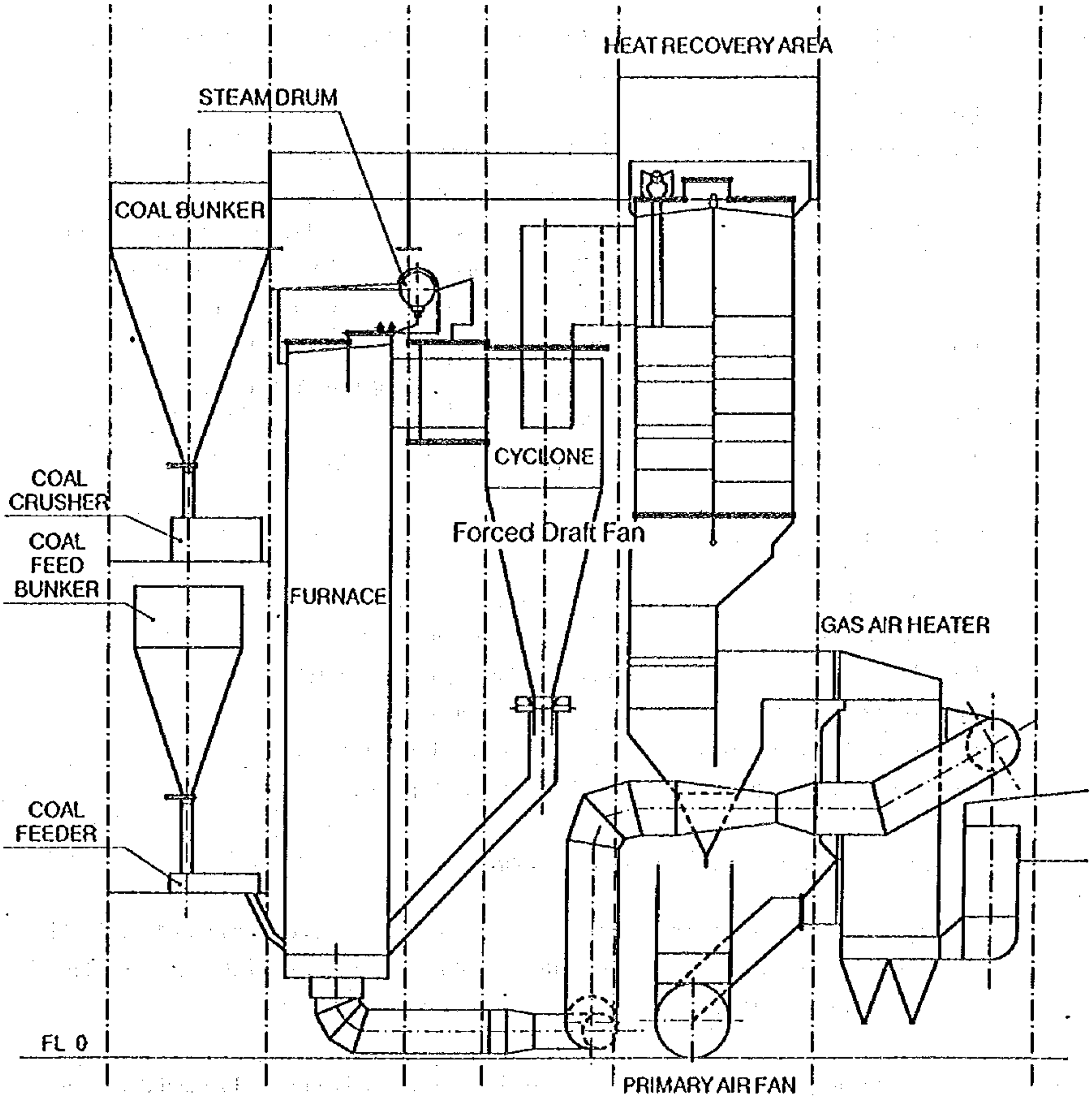


Figure 6-6-1 SIDE VIEW OF C-FBC BOILER PLANT

6.7 Steam Turbine

6.7.1 Steam Turbine

(1) Specification of Steam Turbine

(a)	Type	: Tandem compound, two cylinder, double flow-exhaust, reheat turbine
(b)	Number	: Two (2)
(c)	Rated output	: 230 MW without the district heating 200MW with the district heating
(d)	Steam conditions	: Main steam pressure 169 kg/cm^2 (at turbine inlet) Main steam temperature 538°C (at turbine inlet) Reheat steam temperature 538°C (at turbine inlet)
(e)	Exhaust pressure	: 50 mmHg. abs. (at the rated condition) 90 mmHg. abs. (at the capability condition)
(f)	Speed	: 3,000 rpm
(g)	Governing system	: High pressure type EHC system

(2) Steam Turbine Auxiliaries

(a)	Main oil tank	: One (1) set per unit
(b)	Auxiliary oil pump	: One (1) set per unit
(c)	Jacking oil pump	: One (1) set per unit (if necessary)
(d)	Gland steam condenser	: One (1) set per unit
(e)	HP/LP turbine bypass system	: Each 30% x One (1) set for each unit
(f)	Condensate pump	: 100% x two (2) sets per unit

6.7.2 General Arrangement in the Turbine Building

(1) The new turbine building should be of two (2) floors structure, and the operating floor should be same level as that of the existing turbine building because a part of the existing turbine building will be reused.

(2) The turbine generator auxiliaries, etc. should be arranged on the ground floor and the turbine generator proper, etc. should be arranged on the operating floor.

The turbine generator should be arranged perpendicular to the longitudinal direction of the turbine building.

6.7.3 Condenser and Circulating Water System

(1) Specification of Condenser

(a)	Type	: One (1) pass, horizontal surface type, divided water box
(b)	Turbine exhaust pressure	: 50 mmHg abs.
(c)	Inlet cooling water temperature	: 21°C (Design point)
(d)	Cleanness factor	: 0.85
(e)	Turbine exhaust steam flow	: 458 t/h (at 230MW)
(f)	Turbine exhaust steam enthalpy	: 565.3 kcal/kg
(g)	Condenser tube	: • Tube material : 90-10 Cupro-nikkle • Outer diameter : 31.75 mm • Thickness : 1.00 mm
(h)	Number of tube pass (N)	: One (1)
(i)	Velocity of cooling water in tubes (V)	: 2.0 m/sec.
(j)	Condensate water temperature	: 38.4°C (saturated temperature at 50 mmHg abs)

(2) Circulating Water Facilities

(a) Circulating Water Pump

① Type : Vertical mixed-flow pump
② Number : Five (5) sets per two (2) units (one set for common standby)
③ Capacity : 18,700 m^3/hr/pump

(b) Air Removal Equipment

Each one (1) set of main ejector and starting air ejector should be adopted for each unit.

(c) Condenser Protection System

Screen system and tube cleaning equipment are provided as condenser protection system. As the existing screen facility is deteriorated, it should be replaced with new one. One (1) set of condenser tube cooling equipment should be equipped for each unit.

6.7.4 Feedwater Heating System

(1) A six (6) heater system as mentioned below shall be adopted for the replacing plant, taking into consideration the experiences in the 200MW class power plants and economical study.

(a) Three (3) low pressure feedwater heaters + Deaerator + Two (2) high pressure feedwater (total six (6) stages)

(2) Type of Feedwater Heater

Horizontal shell and U-tube type heat exchangers are adopted for the replacing plant, as a result of the comparison between horizontal or vertical types in reliability, maintainability, installation space and cost.

(3) Type of Deaerator

Spray cum tray type deaerator is adopted for the replacing plant taking its experiences into consideration.

(4) Tube Materials

(a) The following materials are recommended in view of their experiences.

① Low pressure feedwater heater

Stainless steel

② High pressure feedwater heater

Carbon steel

6.7.5 Boiler Feed Pump

(1) Boiler Feed Pump

(a) Type : Motor driven, horizontal multistage centrifugal barrel type with booster pump and water injection seal system

(b) Number : Three (3) sets (One (1) set for standby)

(c) Capacity : 50% each

(2) Emergency Feedwater Facilities

(a) Emergency feedwater pump : 15% x One (1) set

(b) Emergency feedwater tank : 15% of the rated feedwater flow to be supplied for 30 minutes.

6.7.6 Bearing Cooling Water System (Unit Auxillarles Cooling Water System)

(1) Bearing cooling water system

As a result of study on and comparison between closed circuit type system and open storage type one, closed circuit type systems should be adopted for the replacing plant. Figure 6-7-6 shows flow diagram of auxiliary cooling water system.

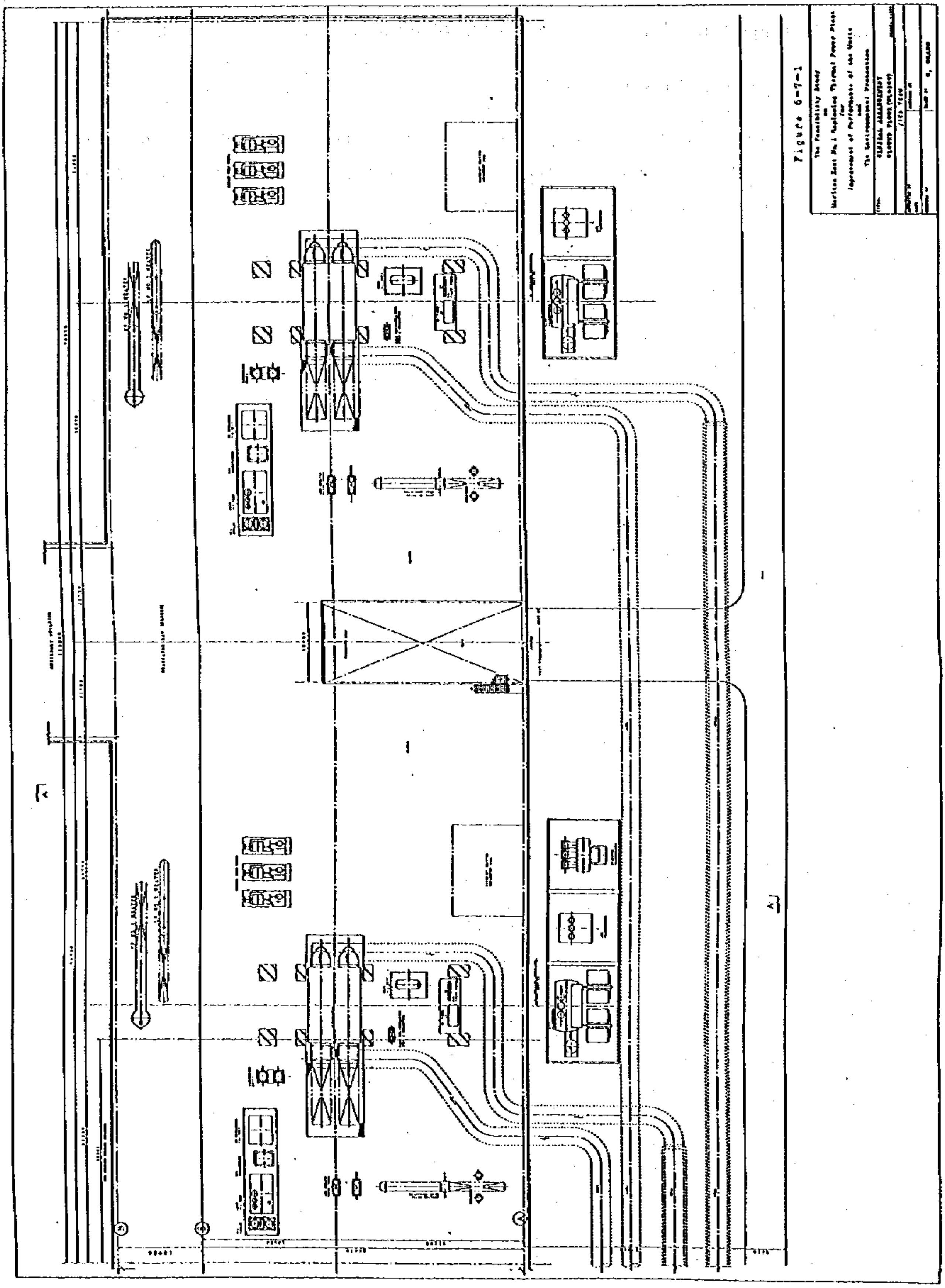


Figure 6-7-1

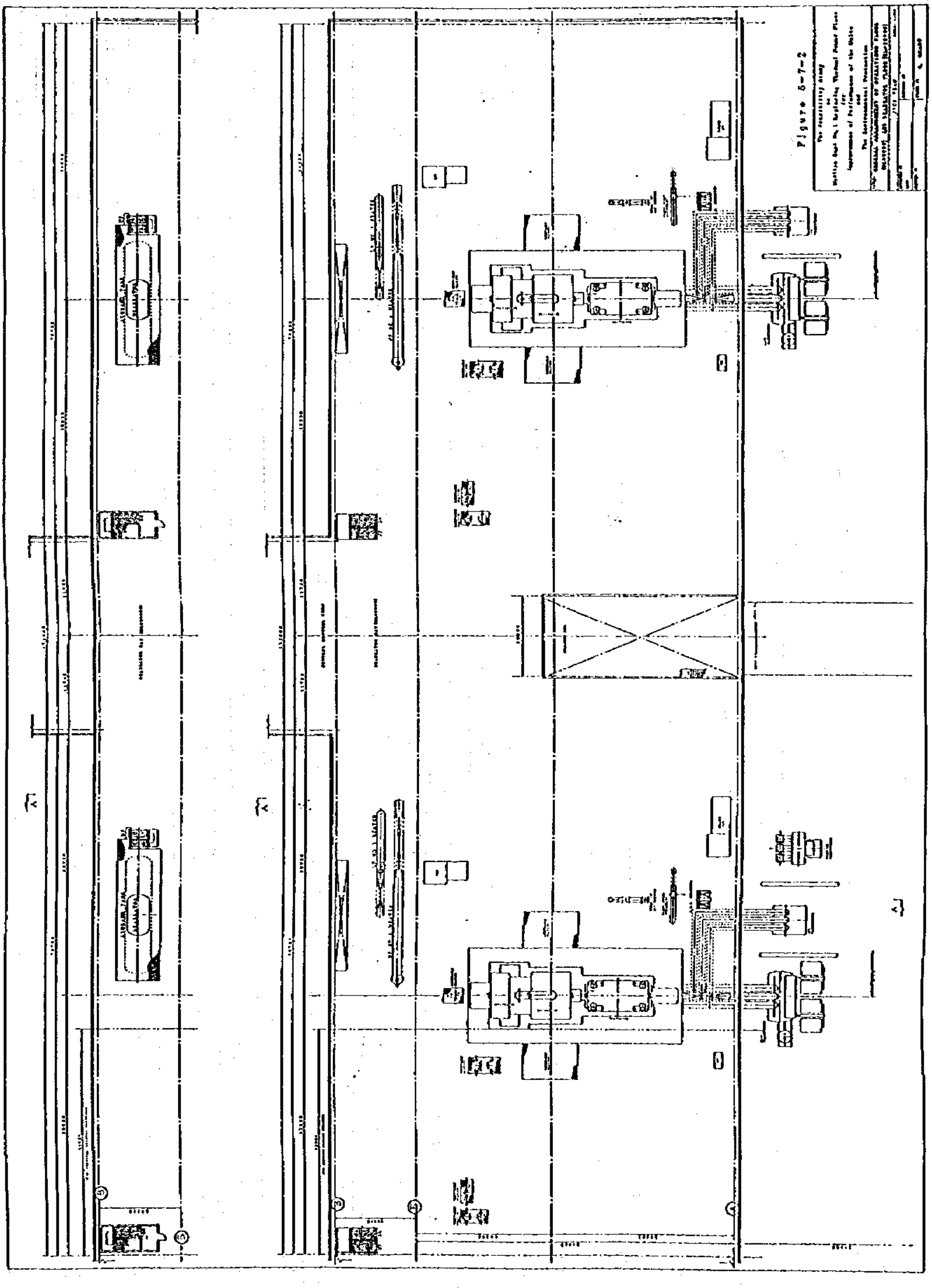
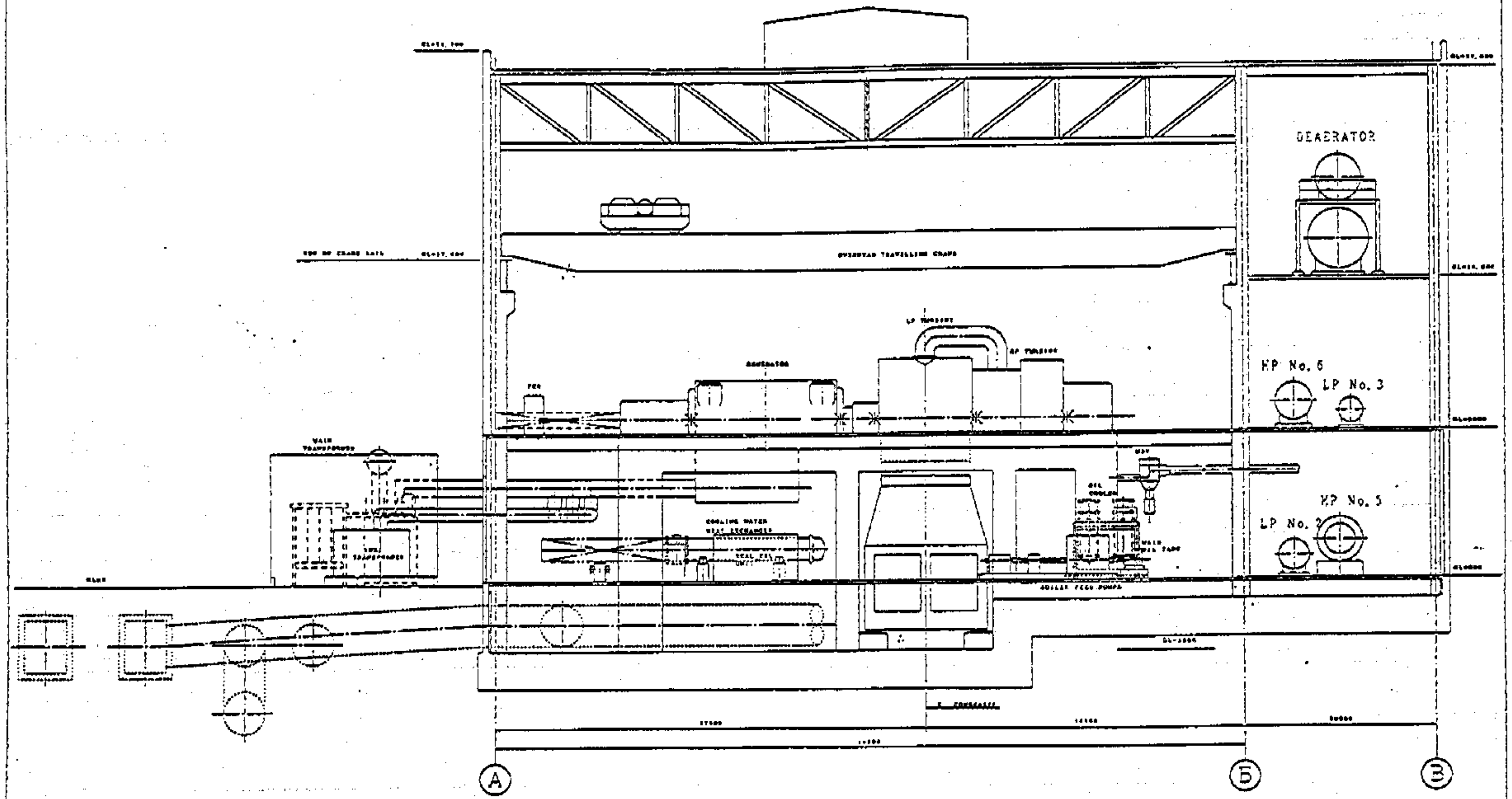


Figure 6-7-2



VIEW A—A

Figure 6-7-3

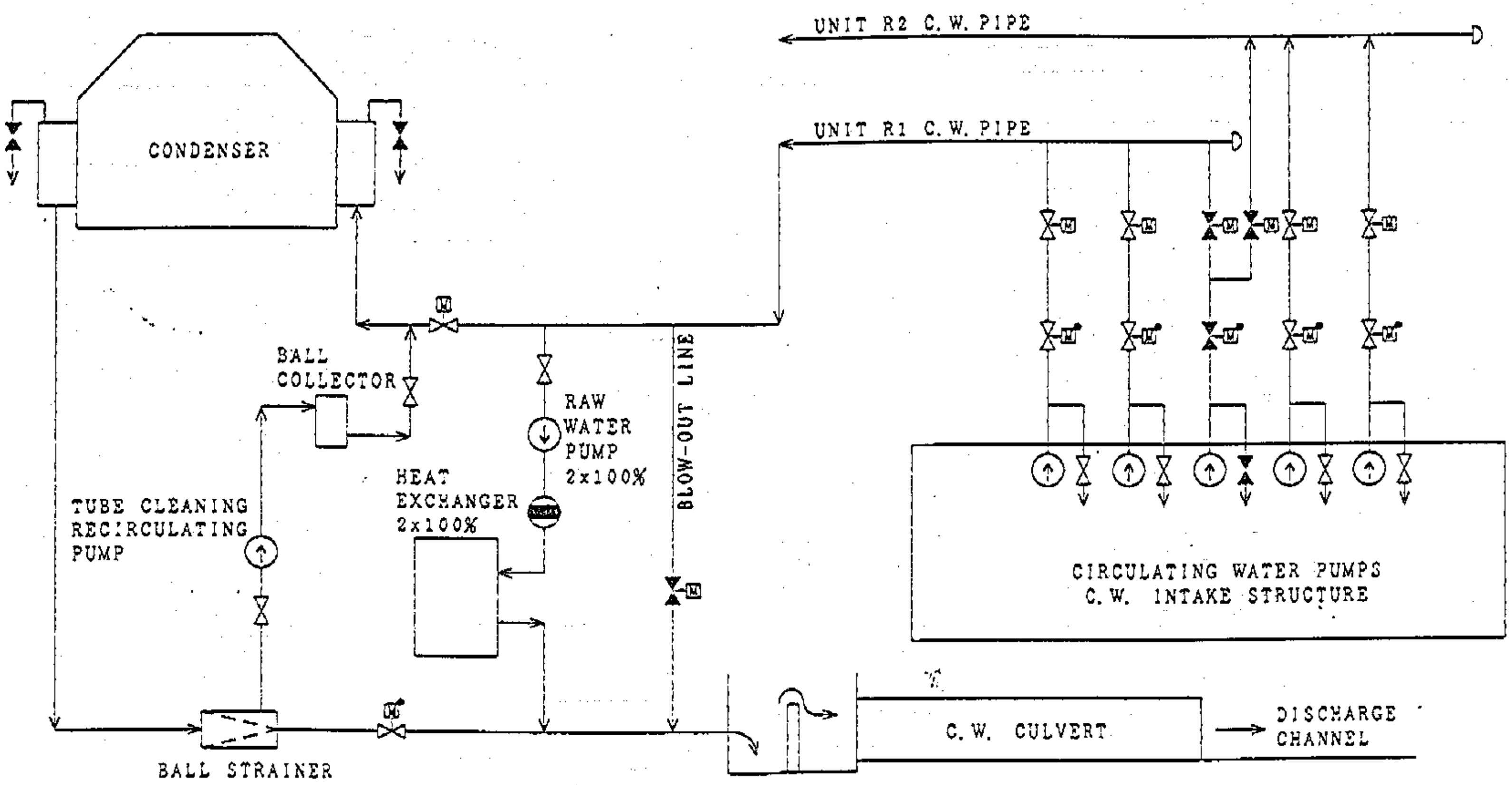


Figure 6-7-4

The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of Performance of the Units
and
The Environmental Protection

TITLE: FLOW DIAGRAM OF CONDENSER COOLING WATER SYSTEM

JICA TEAM

DRAWN BY: H. OKANO

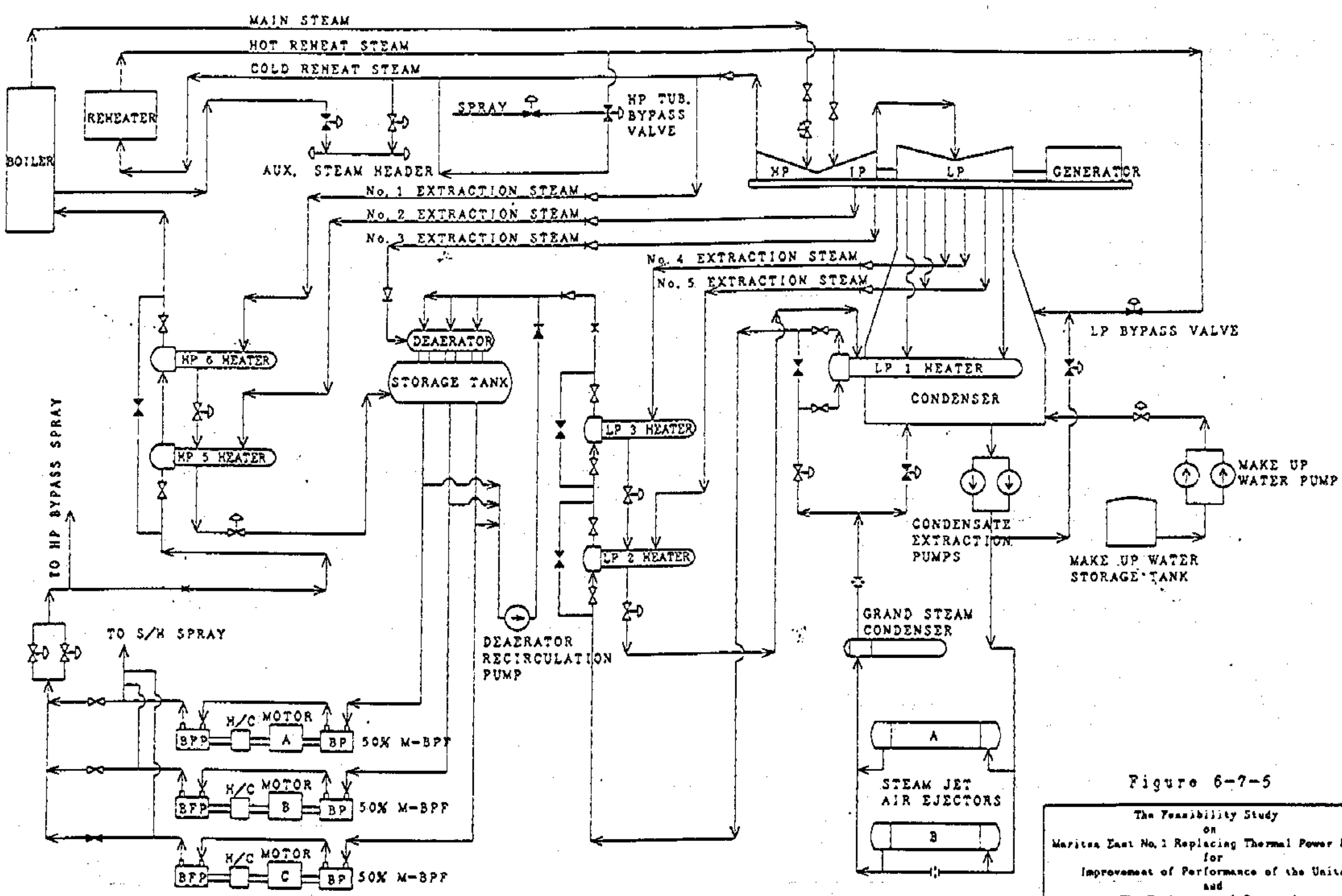


Figure 6-7-5

The Feasibility Study on Maritsa East No.1 Replacing Thermal Power Plant for Improvement of Performance of the Units and The Environmental Protection
TITLE: FLOW DIAGRAM OF CONDENSATE, FEEDWATER AND MAIN STEAM LINE
JICA TEAM
DRAWN BY K. OKANO

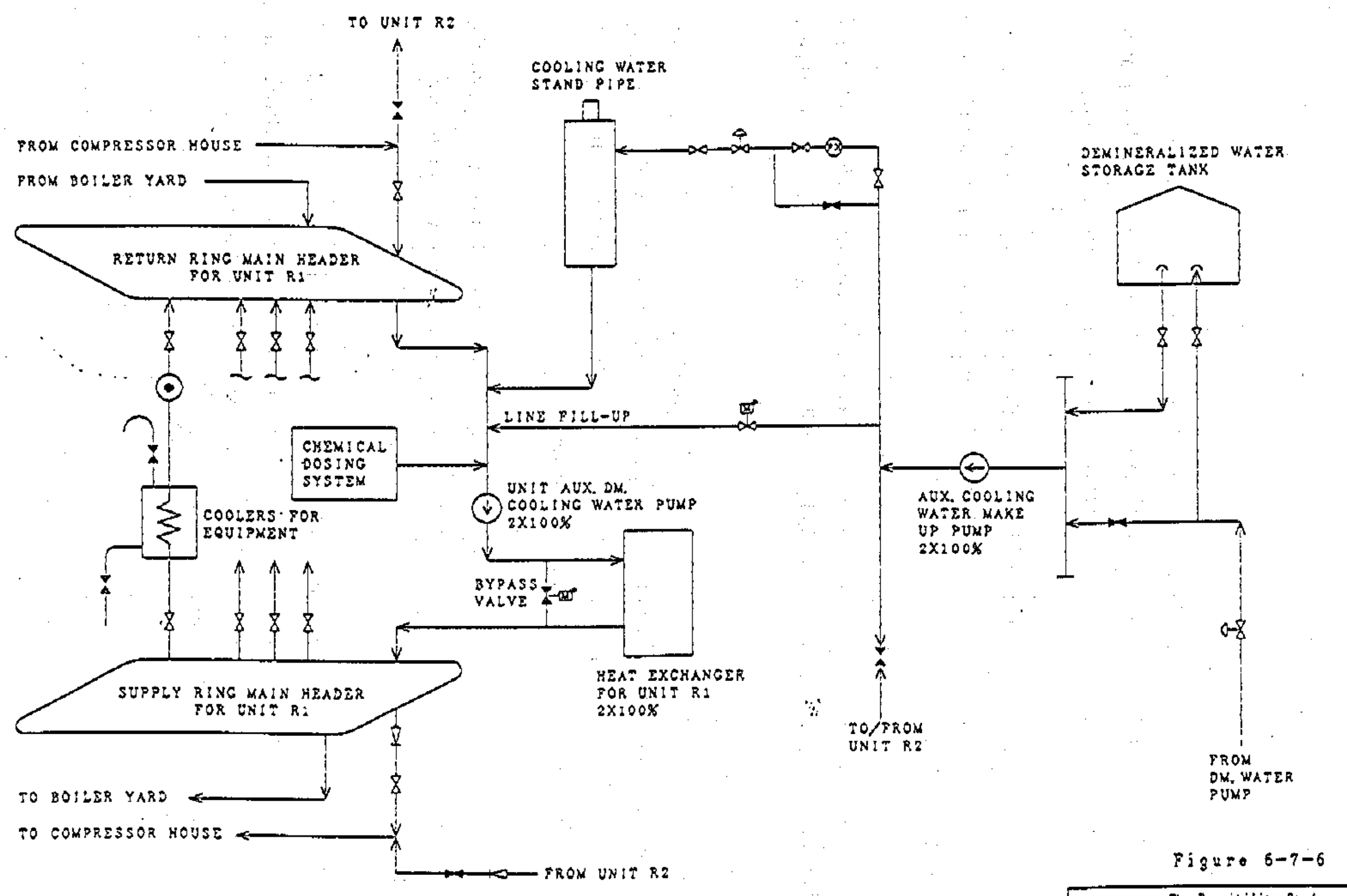


Figure 6-7-6

The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of Performance of the Units
and
The Environmental Protection

TITLE: FLOW DIAGRAM OF AUXILIARY
COOLING WATER SYSTEM

JICA TEAM

DRAWN BY: K. OKANO

6.8 Generator Equipment

6.8.1 Generators and appurtenant

(1) Conditions for study

(a) The generators to be adopted should be coupled directly to the steam turbine and be a horizontal, cylindrical, revolving-field type, three-phase AC synchronous generator of an explosion-proof construction. They should also be capable of 105% output operation.

(b) The hydrogen gas cooling system should be applied for the stator and rotor of the generators to increase the cooling effect, reduce the dimensions and weight of generator and ultimately save the equipment cost.

This cooling system has been applied to many generators of the equivalent class. It features good operability and easy maintenance, and is actually in use at the ME Nos. 2 and 3 Power Plants.

(c) The hydrogen gas generator should be installed in the premises while the sealed oil processor required for oil sealing of the hydrogen gas should be installed on the 1st floor. In addition to an AC-driven oil pump (220 V, 100% capacity x 1), a DC-driven oil pump (220 V, 100% x 1) should also be installed as an emergency back-up.

(d) The excitation equipment should be of a static type thyristor excitation system, and the power source should be supplied from an excitation transformer connected to the generator circuit.

(e) Consisting of an automatic voltage regulator, field regulator circuits, detectors, amplifiers and other components, the excitation equipment should be equipped with the reactive power regulator, power system stabiliser and high and low (voltage) excitation limiters to improve the static and dynamic stability of the power system.

(f) The generator main circuitry should be of a unit system configuration, connected to the main transformer through an isolated phase bus (IPB), and branched to the station service transformer, excitation transformer, power transformer (PT) and surge absorber (SA). Moreover, the generator synchronising circuit breakers should be connected to the 220 kV circuit on the main transformer high voltage side.

(2) Results of study

(a) Generator specifications

① Three-phase AC synchronous generators directly coupled to the steam turbine, with horizontal-cylindrical layout, revolving-field type and explosion-proof construction.

② Quantity	:	2 sets
③ Rated capacity	:	271,000 kVA
④ Power factor	:	0.85 (delay)
⑤ Voltage	:	14.7 kV
⑥ Frequency	:	50 Hz
⑦ Rotation speed	:	3,000 rpm
⑧ Cooling system	:	Hydrogen gas cooling for both stator and rotor
⑨ Hydrogen gas pressure	:	3.2 kgf/cm^2
⑩ Connection system	:	Star
⑪ Excitation system	:	Static excitation (excitation transformer) type

(b) Excitation equipment

① Type	:	Excitation transformers, with quick-response excitation using thrystor
② Voltage	:	500 V DC
③ Quantity	:	2 sets
④ Drive system	:	Separately-installed, static type

(c) Hydrogen and sealed oil equipment for generators

① Vacuum pumps

Type	:	Rotary
Quantity	:	2 sets
Vacuum	:	1 x 10-2 mmHg
Motor	:	1.5 kW

② Main sealed oil pump

Type	:	Gear pump
Quantity	:	2 sets
Discharge pressure	:	8.5 kgf/cm2
Motor	:	15 kW

③ Emergency (back-up) sealed oil pump

Type	:	Gear pump
Quantity	:	2 sets
Discharge pressure	:	7.4 kgf/cm2
Motor (DC)	:	11 kW

④ Hydrogen gas dryer

Type	:	Silica gel filled, heater blower type
Electric heater	:	0.1 kW x 1
Blower	:	0.2 kW x 1
Quantity	:	2 sets

⑤ Hydrogen gas cooler

Type	:	Surface cooling	
Quantity	:	4 sets	
Gas temperature	:	Inlet	85°C
		Outlet	45°C
Cooling water temperature	:	Inlet	35°C
		Outlet	45°C

6.9 District Heating System

6.9.1 District Heating System

(1) Heat source for the hot water is taken from the intermediate pressure turbine outlet.

(2) Water for the district heating is warmed by the steam in the heat exchanger installed on the ground floor in the turbine building, and hot water is supplied by the hot water transfer pump installed on the same floor. The steam drain from heat exchanger shall be recovered to the condenser.

(3) The hot water shall be circulated between the power plant and the Galabovo district by using the existing pipelines.

6.9.2 Specification of District Heating Facilities

(1) Heat Exchanger

(a) Type : Vertical type

(b) Number : One (1) set per unit

(c) Capacity : 100% of the rated hot water quantity

(2) Hot water Transfer Pump

(a) Type : Horizontal pump

(b) Number : Three (3) sets per unit

(c) Capacity : 50% of the rated hot water flow per flow

The concept of District Heating System is shown in Figure 6-9-3.

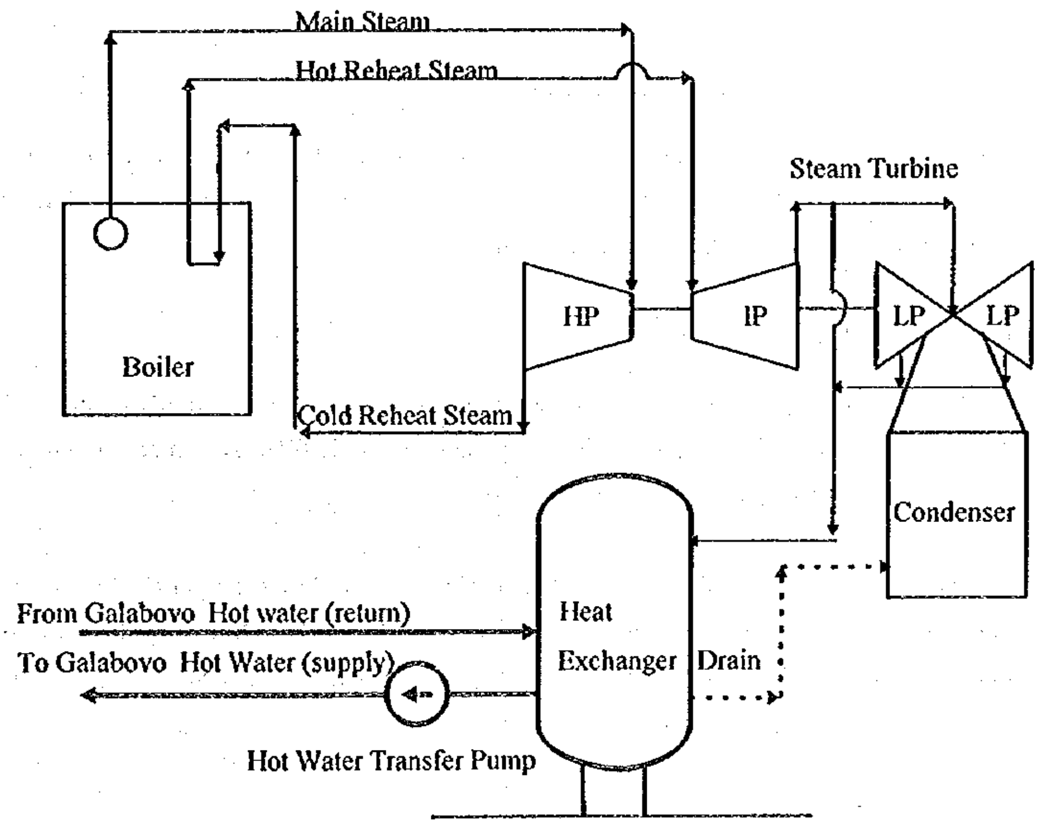


Figure 6-9-3 Flow Diagram of the District Heating System

6.10 Environmental Protection Facilities

6.10.1 Dust Removal Facility

(1) Properties of FBC Boiler Ash

The following is a description of the properties of the ash discharged from the FBC boiler.

(a) Shape of dust particle

Ash becomes fine in the fluid bed boiler due to a cyclone installed in the flue gas treatment system in addition to the dispersion of the degraded fluidized bed material. With the FBC boiler and pulverized coal firing boiler having different combustion mechanisms and different flame temperatures, the shape of generated ash also becomes different.

While the shape of the fly ash from the pulverized coal firing boiler is globular, the ash of the FBC boiler is not spherical and porous.

(b) Components and Electrical Resistivity of Dust

The major components of dust are SiO_2, Al_2O_3, $CaSO_4$, CaO, and $CaCO_3$. SiO_2 and Al_2O_3 are components found in coal ash and $CaSO_4$, CaO, and $CaCO_3$ are derived from the dispersion of powdered fluidized bed material.

(2) Comparison of Dust Collector

Coal fired thermal power plants employ electrostatic precipitators, fabric filters and cyclones as dust removal facilities. Electrostatic precipitator and fabric filter are compared in this study except cyclones because of low removal efficiency.

The comparison between dust collectors in Table 6-10-1-1 shows that an ESP is considered superior when the operational maintainability and reliability of the filter bag etc. is taken into consideration. In this F/S, an ESP is to be considered because an ESP is also used in the existing plant and the staff is well versed in its operation.

(3) Outline of ESP Facility

The particle charging methods are roughly divided into direct current charging (single pole, unidirectional), alternating current charging (single-pole, bi-directional), and pulse charging. As it provides a simple structure and is quite inexpensive, the direct-current (DC) charging system is the most popular ESP charging equipment.

It is necessary to raise the voltage and current density in order to increase the charging efficiency. However, in the case of a conventional DC corona charging system, the charging efficiency decreases as the corona current becomes inequality when back corona ionization occurs. Pulse charging systems are now drawing attention as a system able to offset this defect, especially for high-resistivity dust. Uniformed corona current can be obtained whole through the discharge electrode, and a peak voltage higher than that of DC charging is obtained and the collecting efficiency is improved by changing the crest value, amplitude, and cycle of the pulse. However, pulse charging would serve to further increase the cost of electric power facilities. On the other hand, intermittent charging method is also available, by which the output of the continuous charging system is eliminated at regular intervals. This method is adopted here in order to save electricity, to control reverse electrolysis, and to attain a little higher efficiency.

Regarding the relationship between boiler operation and the ESP performance, that performance progressively deteriorates when the ESP is operated with no hammering during the process from boiler ignition, parallel induction, through increment of boiler load, or when boiler operation is stopped. However, assured stable performance is as good as that obtained during regular boiler operation of boilers by applying periodical hammering to the ESP.

Below is an ESP facility outline when an assumed quantity of 5% of processed gas and a 10% inlet dust quantity is included in the design parameters.

a)	Coal type:	Bulgarian Lignite
b)	Inlet gas flow rate:	1,359,000 m^3 N/h (wet)
c)	Inlet dust concentration:	50 g/m^3 N
d)	Outlet dust concentration:	0.1 g/m^3 N
e)	Outlet gas temperature:	165°C
f)	Temperature lowering:	5°C
g)	Pressure loss:	20 mm Aq
h)	Hopper capacity:	Sufficient for 12-hour operation

Table 6-10-1-1 Dust Collector Comparison (1/2)
(Outlet Dust : 100 mg/m^3 N)

Item	Electrostatic Precipitator	Fabric Filter
1. Outline	Its performance would be affected by changes in the conditions around inlet as the specifications are based on those conditions (gas quantity, gas temperature and composition, content and properties of dust etc.)	This would not be affected by the type of coal or boiler operation conditions as dust in the gas is physically collected by a filter cloth.
2. Spec.		
(1) Pressure loss	Small (approx. 20 - 25 mmAq)	Large (approx. 150mmAq)
(2) Installation size	Same as bag filter	Same as an ESP
(3) Performance	Dust collection performance varies in accordance with the inlet conditions such as the type of coal used.	Only little affected by conditions such as coal and operational conditions.
(4) Reliability	• Employed for more than 20 years in coal-fired thermal power plants. • Requires constant monitoring and recording of charging conditions.	• Heavily dependent on the reliability of the filter bag. • Filter bag service life is 2 - 3 years. • The method of dust concentration and isolation require consideration as the outlet dust content could exceed the standards if the filter bag is broken. • Moisture proof is not known well.
(5) Operational Maintain-ability	• Possible to determine component anomalies by monitoring and recording charging voltage and current. • No major maintenance problems.	• Filter bag damage can be determined by monitoring and recording the inlet/outlet gas pressure loss and outlet dust concentration etc. However, methods to detect the damaged parts and isolation methods require examination. • Filter bag must be replaced regularly.

Table 6-10-1-1: Dust Collector Comparison (2/2)
(Outlet Dust : 100 mg/m3 N)

Item	Electrostatic Precipitator	Fabric Filter
3. Economy		
(1) Facility cost	High	Low (dependent on the cost of filter bag)
(2) Annual running cost	Low	High
(3) Annual expenses	Low	High
4. Evaluation	Performance is affected by the inlet conditions. However, this causes no serious problem unless the electrical resistivity of the particles change drastically. Optimum design is possible as the facility costs and annual running costs change in accordance with the outlet dust concentration.	Performance almost stable regardless of the inlet conditions. However, since the facility costs and annual running costs do not change regardless of the designed outlet dust concentration, this system becomes advantageous when the outlet dust concentration is strict.

6.10.2 Waste Water Treatment System

(1) Waste Water Treatment Method and System

(a) Waste water treatment should have "Low salt concentrated waste water treatment method" and "High salt concentrated waste water treatment method".

(b) Both methods consists of coagulation sedimentation, filtration and neutralization, but high salt one is equipped with countermeasures of reducing COD.

(c) Figure 6-10-2-1 shows flow diagram of waste water treatment system.

(2) Specifications of Waste Water Treatment Equipment

(a) Low concentrated waste water treatment equipment

① Coagulation sedimentation equipment	:	1,500 m^3/day x 1 set	
② Filter	:	1,500 m^3/day x 1 set	
③ Neutralization equipment	:	1,500 m^3/day x 1 set	
④ Synthetic absorbent equipment	:	Chemicals: Hydrogen peroxide solution	
		Un-steady waste water batch processing	
⑤ Waste water pond	:	Steady waste water pond	400 m^3 x 2
		Un-steady waste water pond	500 m^3 x 1

(b) High concentrated waste water treatment equipment

① Coagulation sedimentation equipment	:	150 m^3/day x 1 set
② Filter	:	150 m^3/day x 1 set
③ Neutralization equipment	:	150 m^3/day x 1 set
④ Synthetic absorbent equipment	:	150 m^3/day x 1 set
⑤ Waste water pond	:	Steady waste water pond
		1,500 m^3 x 1 (for AH)
		Un-steady waste water pond
		1,000 m^3 x 1 (for EP)

(c) Waste water pit for water treatment plant

① Low concentrated waste water	:	900 m^3 x 1
② High concentrated waste water	:	90 m^3 x 1

(d) Waste water pit for pre-treatment plant

① Low concentrated waste water : 200 m^3 x 1

(e) Unit waste water pit

① Low concentrated waste water : 35 m^3 x 1

② High concentrated waste water : 3 m^3 x 1

(f) Blow pit : 100 m^3 x 1

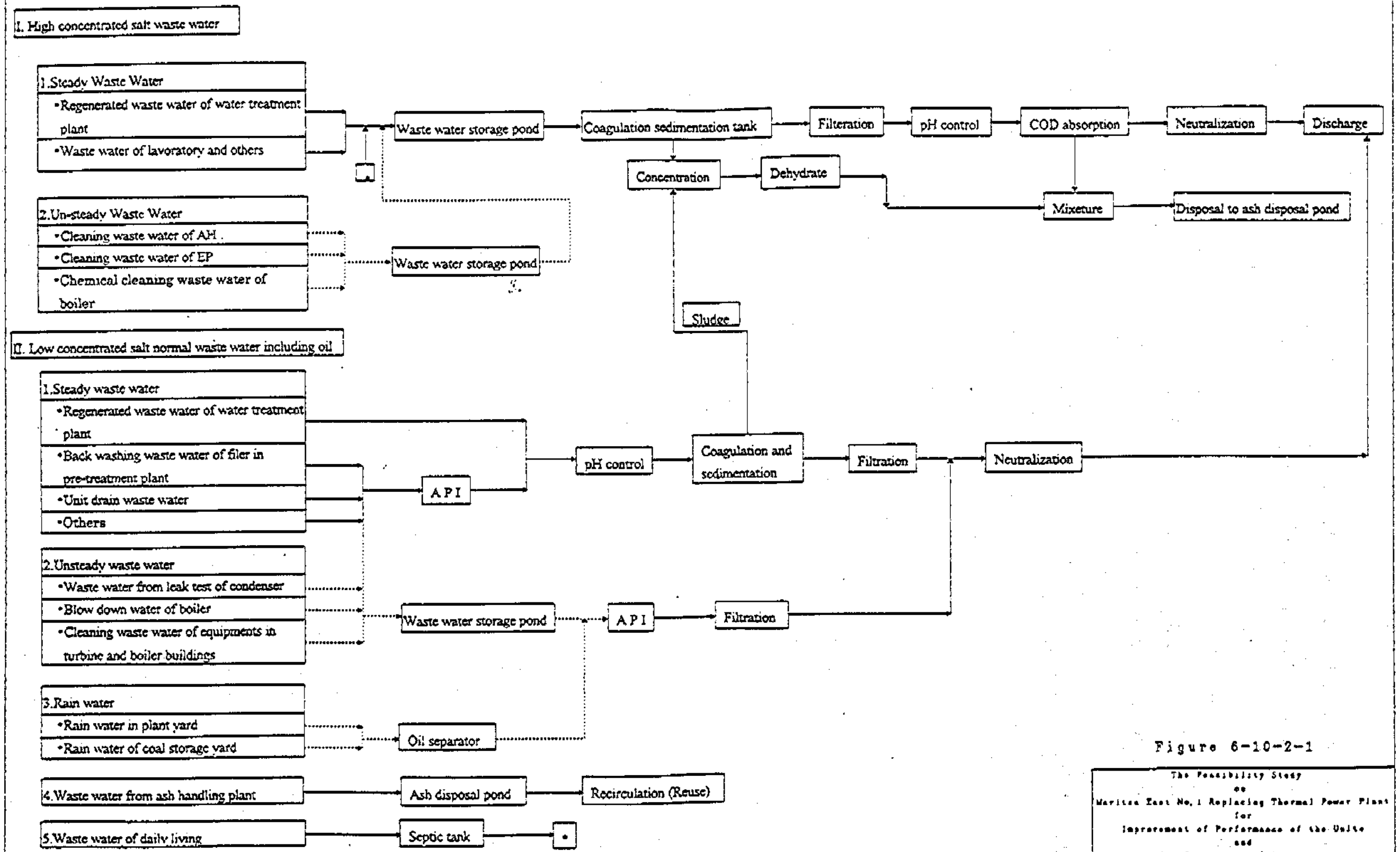


Figure 6-10-2-1

The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of Performance of the Units
and
The Environmental Protection

TITLE: FLOW DIAGRAM OF WASTE WATER TREATMENT SYSTEM

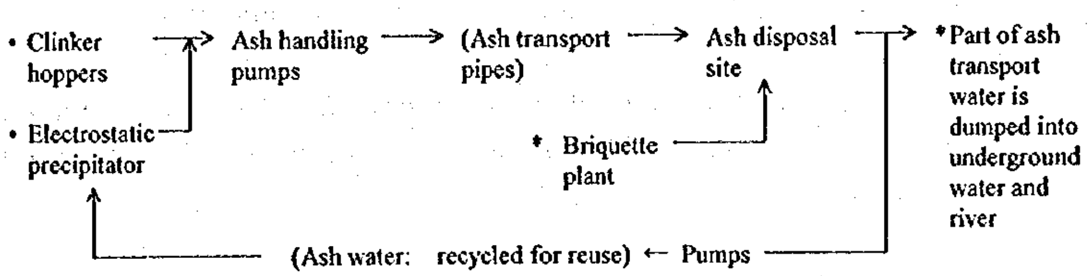
JICA TEAM

6.11 Ash Handling Facilities

(1) Study Parameters

(a) Existing ash handling is outlined below in flowchart form.

Ash transport water is recycled as diagrammatically shown in Figure 6-11-1.



(b) As for the characteristics of the existing ash transport system, ash transport pipes are installed to an ash dumping site from individual ash handling pumps (6 sets in all) on a one-to-one basis. A manifolding discharge valve arrangement is installed on the piping in the vicinity of the ash disposal site so that valves may be opened/closed selectively to achieve uniform discharge.

(c) The existing ash disposal site is as follows:

- Area : 300 ha (3 km^2)
- No. 1 and No. 2 sections : already filled to capacity (14 m in depth and 30 cm in cover-up soil thickness)
- No. 3 section (A and B subsections): B in current use with a remaining capacity of 6,765,800 m^3 ≒ roughly equivalent to 12 years' volume of ash (at 200 MW)

(d) The amount of ash the reconstructed boilers is projected to discharge is as follows:

- Amount of dry ash (coal ash, by-product gypsum, limestone, impurities, etc.)
  350 t/h (≒ 173 t/h × 2 units), 8,400 t/d, 2,150,000 t/y
  (Breakdown) 350 t/h: On bottom = 220 t/h Beneath ECO = 20 t/h
  Beneath AH = 20 t/h Beneath ESP = 90 t/h
- Amount of ash discharged (Water content: 30%)
  450 t/h (≒ 173 t/h × 2 units × 1.3), 10,800 t/d

(2) Study Results

(a) Design specifications based on the above are as follows:

1) Supposing that the ash height specific gravity is 1.0, the existing ash disposal yard can be used for less than 3 years (dry ash base). However, since combustion ash of a fluidized bed combustion boiler contains Ca component, reaction with water generates heat and increases pH (13 or more) so that its control method is very difficult.

Therefore, as a final treatment method, ash should be disposed of in a surface soil disposal yard (Drianovo: 17km^2) 7km ahead southeast from the power plant by using a freight car for transporting coal mine surface soil (41 t/car).

The coal mine surface soil disposal yard and the rough position of the coal mine are shown in Figure 4-1-3.

2) If ash is conveyed by stream, there is a problem such as pipe clogging caused by Ca component in ash.

Therefore, an air current transport system is adopted from the ash collecting equipment to the ash loading equipment, and after the ash loading equipment is humidified, ash is conveyed to the transport freight train by conveyer.

3) As ash recovered from the bottom of the furnace cannot be cooled directly by water, an ash cooler shall be separately installed.]

4) The ash loading facility shall be constructed at the point of loading onto freights (which is located behind the neighboring briquette plant) to cope with moistening-caused problems such as solidification and heat generation. Ash shall, therefore, be moistened (20% to 30%) prior to loading--and conveyors and trippers shall be designed to be heat-resistant.

5) On the assumption that a single loading session takes an hour, and ash transport trains shall be operated 12 hours a day, it becomes necessary to operate 12 trains, each made up of 22 cars as calculated below:

6) The capacity of ash transit tanks shall be designed to be large enough (10 hours: 2,000 m^3), as determined by the footprint of ash-collection equipment to be installed atop the tanks.

7) The combined capacity of silos (for storage and loading purposes) shall be large enough to last 2 days (48 hours). The loading silo shall have one day's capacity (4,200 m^3/day). And, the remaining capacity required shall be met by the storage silos. (4,200 m^3)

8) The (storage and loading) silos shall have systems that permit the receipt of ash from both R1 and R2 units.

9) The storage silos shall be equipped with emergency facilities (to take ash out of storage on trucks) which will be used in the event of trouble with loading facilities or the like.

(b) The specifications of major facilities have been determined on the basis of the above design specifications are as follows.

They are shown in flowchart form in Figure 6-11-2.

1) Ash collection system (BM: Ash on furnace bottoms, FA: ECO, AH, and ESP ash)

- BM ash coolers: Rotary ash coolers
  [40 t/h, 3 sets/unit]

- Ash transport pipes (10B): (For BM) 3 lines/unit × 2 units
  (For FA) 2 lines/unit × 2 units

- Vacuum blowers: Dry-type Roots blowers
  [(For BM) 52 Nm^3/min., 4 sets/unit (1 set for backup)]
  [(For FA) 57 Nm^3/min., 3 sets/unit (1 set for backup)]

- Dust collectors: Integral-type bag filters
  [(For BM) 3 sets/unit]
  [(For FA) 2 sets/unit]

- Ash transit tanks: Cylindri-conical steel tanks
  [2,000 m^3 (15 m across × 11 m high) × 1 set/unit]

2) Ash transport facilities

- Discharge vessel: Cylindri-conical steel pressure vessels
  [50 tons/hour × 4 sets/unit]

- Ash transport pipes (16B): 1 line/unit

- Pressurize blowers: Dry-type Roots blowers
  [210 Nm^3/min., 2 sets/unit (1 set for backup)]

- Ash storage silos: Cylindri-conical steel silos
  [4,200 m^3 (16.5 m across × 20 m high) × 1 silo/unit]

- Dustless unloader: (For use in emergency)
  Dual-shaft paddle-equipped type
  [100 tons/hour (dry ash) × 1 set/unit]

- Dustless unloader-feedwater pumps:
  Centrifugal pumps
  [190 m^3/hour (5 kg/cm2g) × 3 sets/2 units (1 set for backup)]

- Feedwater pits: Rectangular concrete pits
  [8 m wide × 8 m long × 4 m high × 1 pit/2 units]

3) Ash loading facilities

- Discharge vessel: Cylindri-conical steel pressure vessels
  [50 tons/hour × 4 sets/unit]

- Ash transport pipes (18B): 2 lines/unit

- Pressurize blowers: Dry-type Roots blowers
  [270 Nm^3/min., 3 sets/unit (1 set for backup)]

- Ash loading silos: Cylindri-conical steel silos
  [4,200 m^3 (16.5 m across × 20 m high) × 1 silo/unit]

- Dustless unloader: (For regular use)
  Dual-shaft paddle-equipped type
  [250 tons/hour (dry ash) × 3 sets/unit]

- Conveyors: Bucket conveyors (heat-resistant)
  [950 tons/hour (moistened ash) × 1 set/unit]

- Trippers: Belt lifting type (heat-resistant) [950 tons/hour (moistened ash) × 1 set/unit]

(3) Items to be considered for carry out the plan

(a) The amount of water required for moistening ash in preparation for transportation by rail cars varies in accordance with the proportion of Ca components contained in the ash--A large amount of water causes ash to solidify while a small amount of water causes ash to be loose and crumbly. It is, therefore, important to determine the optimum moisture content for in-transit ash in the test-run stage or in a separate study relating to the handling of ash derived from fluidized bed combustion (FBC) furnaces (as to humidification factor, heat generation, and the like) using "Bulgarian" lignite.

(b) Since underground water is flowing beneath the coal-mine topsoil disposal site (at Drianovo, 17 km^2), it is necessary to institute measures to prevent contamination with hazardous substances dissolved out of dumped FBC ash.

As example measures, the following are conceivable:

- Study whether a clay stratum of a disposal yard can be used or not.
- Solidify the bottom layer of a selected dumping area by taking advantage of such properties of FBC combustion ash that it is caked by water.
- It is also very important to analyse and grasp eluted components of FBC combustion ash more accurately in order to study various countermeasures.

(c) Since the operation of coal-mine topsoil transport cars and ash transport cars is expected to be complicated, consideration should be given to the following:

- Freight car operation should be elaborately scheduled.
- Arrangements for liaison and coordination between the coal mining company and the power plant should be devised.
- To deal with freight-car operation which will be complicated, the number of safety operation personnel should be increased to better implement safety management.

(d) Since FBC ash shall be disposed of by using the railway and disposal site owned and operated by the coal mining company, there is a necessity of making prior adjustments/arrangements between the coal mining company and the power plant concerning such matters as the power plant's reconstruction schedule, the sharing of workload (including the employment of operating personnel), the sharing of costs of purchasing rolling stock (freight cars), and other attendant matters that are required to be settled such as ash-disposal contracts.

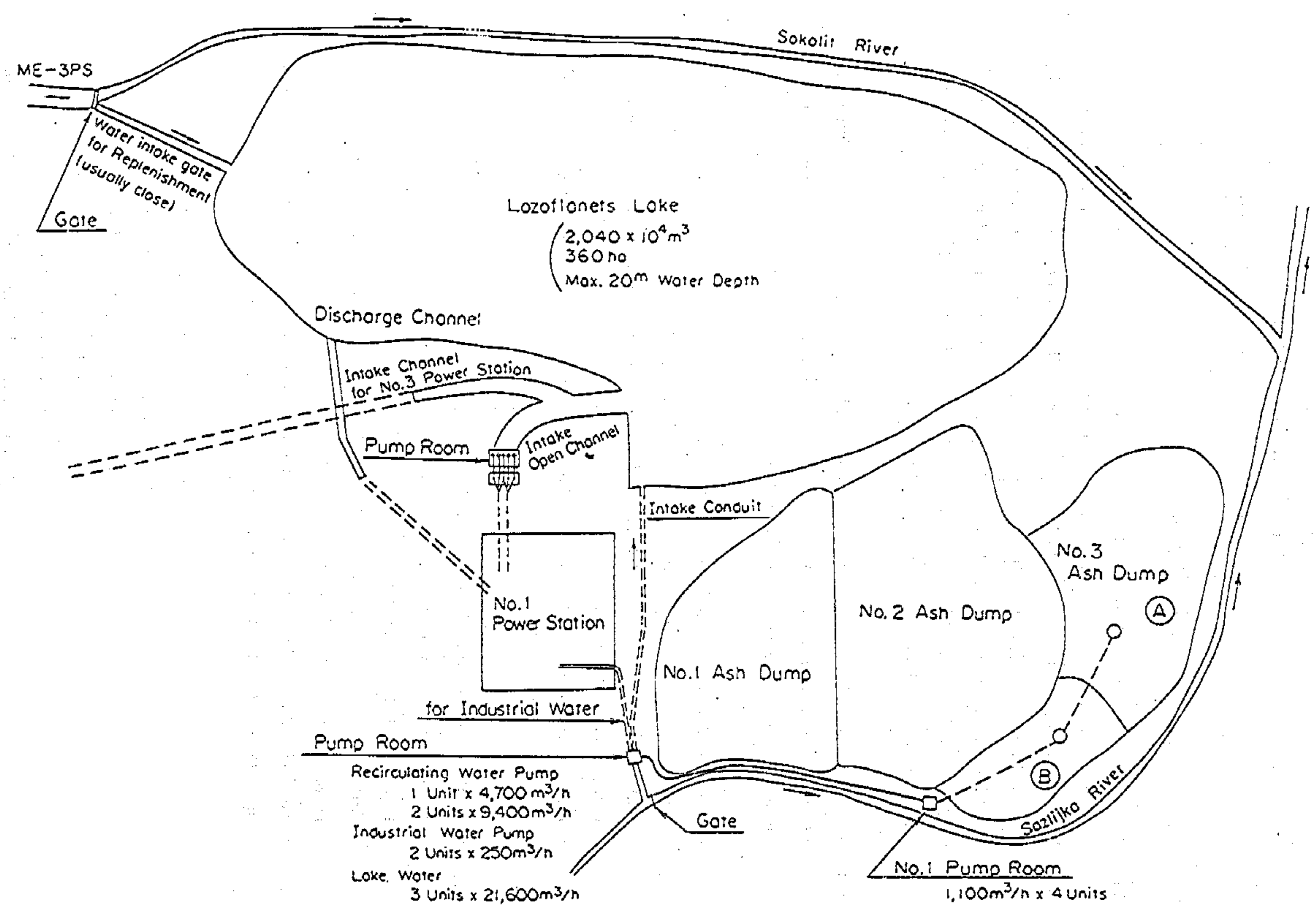


Figure 6-11-1 Water Intake and Discharge System in Power Station

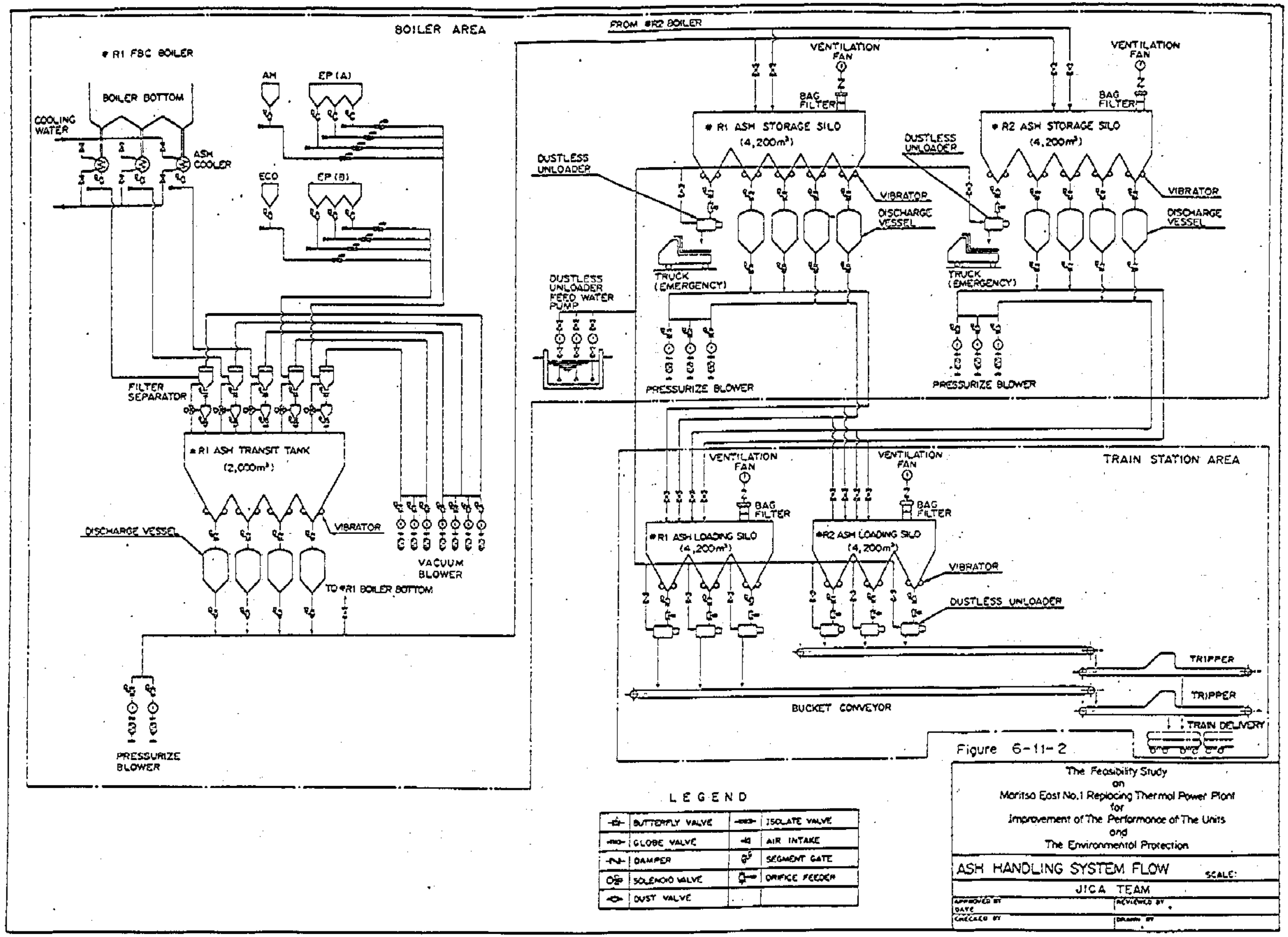

BOILER AREA
R1 FBC BOILER
BOILER BOTTOM
COOLING WATER
ASH COOLER
AH
EP (A)
ECO
EP (B)
FILTER SEPARATOR
R1 ASH TRANSIT TANK
(2,000m³)
VIBRATOR
DISCHARGE VESSEL
VACUUM BLOWER
TO #R1 BOILER BOTTOM
PRESSURIZE BLOWER
FROM #R2 BOILER
VENTILATION FAN
BAG FILTER
R1 ASH STORAGE SILO
(4,200m³)
R2 ASH STORAGE SILO
(4,200m³)
DUSTLESS UNLOADER
VIBRATOR
DISCHARGE VESSEL
TRUCK (EMERGENCY)
DUSTLESS UNLOADER FEED WATER PUMP
PRESSURIZE BLOWER
TRAIN STATION AREA
R1 ASH LOADING SILO
(4,200m³)
#R2 ASH LOADING SILO
(4,200m³)
DUSTLESS UNLOADER
TRIPPER
TRIPPER
TRAIN DELIVERY
BUCKET CONVEYOR
LEGEND
BUTTERFLY VALVE
GLOBE VALVE
DAMPER
SOLENOID VALVE
DUST VALVE
ISOLATE VALVE
AIR INTAKE
SEGMENT GATE
ORIFICE FEEDER
The Feasibility Study
on
Moritso East No.1 Replacing Thermal Power Plant
for
Improvement of The Performance of The Units
and
The Environmental Protection
ASH HANDLING SYSTEM FLOW
SCALE:
JICA TEAM
APPROVED BY
DATE
CHECKED BY
REVIEWED BY
DRAWN BY

Figure 6-11-2

6.12 Plant Water System

6.12.1 Pre-treatment and Water Treatment Method and System

(1) In plant water treatment method, the coagulation and sedimentation method is adopted for pre-treatment plant and the mix bed type with polisher is adopted for water treatment plant, taking consideration of water quality of Sazliika River and the experiences of water treatment plant.

(2) Figure 6-12-1 shows flow diagram of water treatment system.

6.12.2 Specifications of the Main Equipment and Facilities

(1) Pre-treatment Plant

(a)	Type	:	Coagulation, Sedimentation and Filter Method
(b)	Capacity	:	1,500 m^3/day per train
(c)	Number	:	Two (2) sets

(2) Filtered Water Tank

(a)	Type	:	Steel made cylindrical tank (of dome roof type)
(b)	Capacity	:	4,000 m^3/day per one tank
(c)	Number	:	Two (2) sets

(3) Water Treatment Plant

(a)	Type	:	Mix bed type with polisher
(b)	Capacity	:	700 m^3/day per train
(c)	Number	:	Two (2) sets

(4) Demineralized Water Tank

(a)	Type	:	Steel made cylindrical tank (of inner roof type)
(b)	Capacity	:	1,500 m^3/day per one tank
(c)	Number	:	Two (2) sets

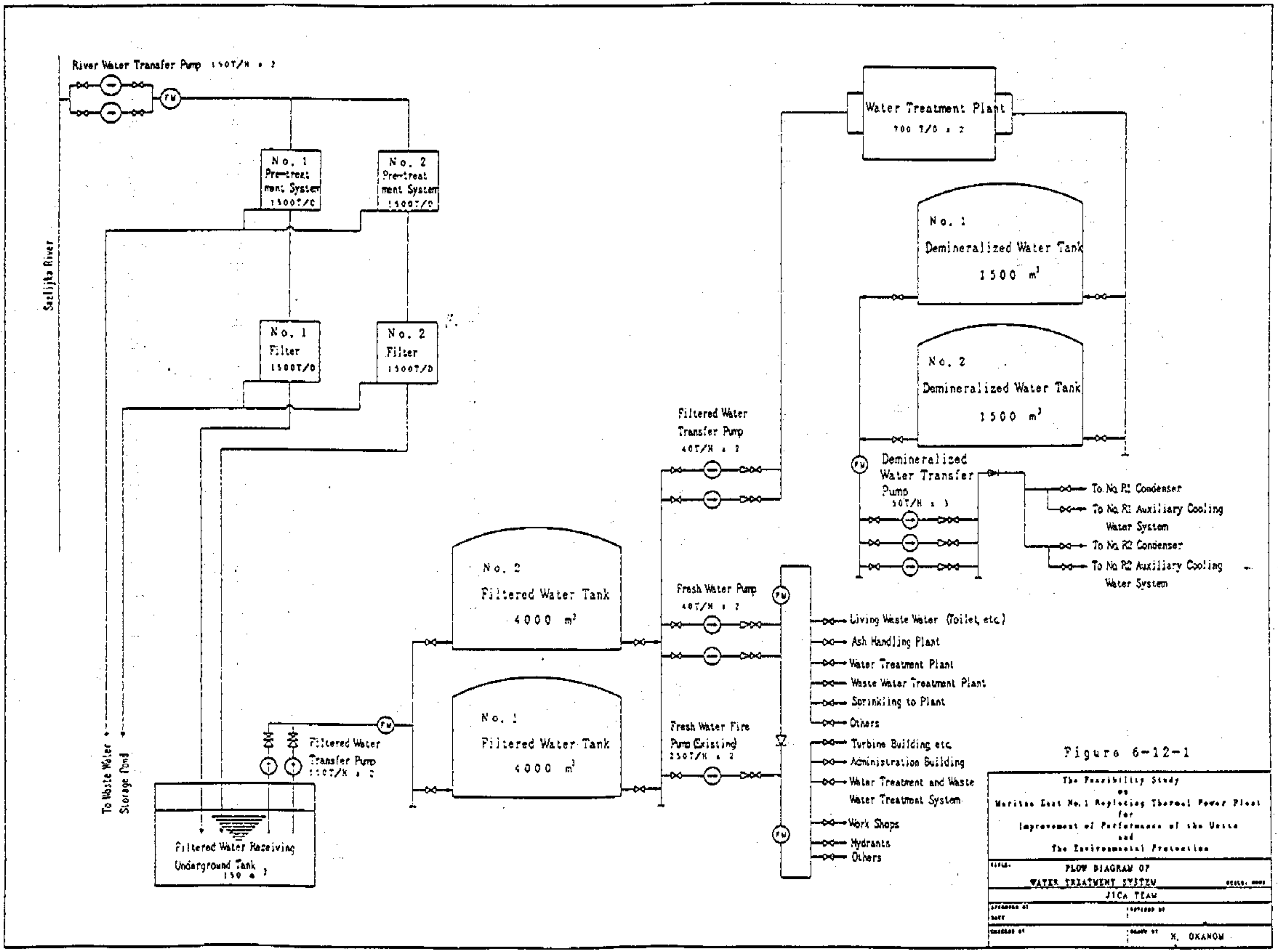

River Water Transfer Pump 150T/H x 2
Sazlijka River
No. 1 Pre-treatment System 1500T/D
No. 2 Pre-treatment System 1500T/D
No. 1 Filter 1500T/D
No. 2 Filter 1500T/D
To Waste Water
Storage Pond
Filtered Water Receiving Underground Tank 150 m³
Filtered Water Transfer Pump 150T/H x 2
No. 2 Filtered Water Tank 4000 m³
No. 1 Filtered Water Tank 4000 m³
Filtered Water Transfer Pump 40T/H x 2
Fresh Water Pump 40T/H x 2
Fresh Water Fire Pump (Existing) 250T/H x 2
Water Treatment Plant 700 T/D x 2
No. 1 Demineralized Water Tank 1500 m³
No. 2 Demineralized Water Tank 1500 m³
Demineralized Water Transfer Pump 50T/H x 3
To No. R1 Condenser
To No. R1 Auxiliary Cooling Water System
To No. R2 Condenser
To No. R2 Auxiliary Cooling Water System
Living Waste Water (Toilet, etc.)
Ash Handling Plant
Water Treatment Plant
Waste Water Treatment Plant
Sprinkling to Plant
Others
Turbine Building etc.
Administration Building
Water Treatment and Waste Water Treatment System
Work Shops
Hydrants
Others
FLOW DIAGRAM OF WATER TREATMENT SYSTEM
JICA TEAM
M. OKANOM

Figure 6-12-1