6.13 Air Service Equipment

6.13.1 Control Air Source

The instrument control air source for the air control of thermal power plant should be installed separately from the station service air sources as described below. However, the instrument air sources to be used exclusively for local equipment (for example, primary water treatment equipment, fuel storage facilities, waste water disposal equipment and other common equipment of power plant) should be installed individually according to these specifications.

(1) Instrument Control Air Piping System

Regarding the control air piping system, refer to Figures 6-13-1-1.

(a) Equipment configuration

The equipment configuration of the control air source piping system should be as listed below:

- Instrument control air compressors
- Instrument control air receivers
- Instrument control air dehumidifiers
- Air filters with mist separators
- Supply headers
- Auxiliary air receivers
- Local instrument boards (LB) and junction boxes (JB)
- Pressure reducing valves
- Piping and valves

(b) Backup system

a. Station service air connector pipe

① The backup piping from the station service air piping should be provided at the instrument control air receiver inlet.

② A separator (for oil, drain and dust separation) should be installed downstream of each air take-out point.

③ In preparation for automatic backup when the control air pressure has dropped, an automatic shut-off value, a pressure regulator valve and a pneumatic type pressure controller should be installed.

Moreover, a bypass valve should be attached to the pressure regulator valve.

b. Control air connector pipe with other unit (This pipe is not required in case it is installed as a common pipe for two units)

The pipes from the two power units should be connected to each other at the control air dehumidifier (dryer) outlet piping.

A limit switch should be installed to make it possible to monitor the opening/closing conditions of this connector valve in the central control room, and such conditions be input to the unit digital control system (DCS).

(c) Division of supply air sources

At the supply header, the control air sources should be divided into the following lines and taken out from the supply master pipe according to individual purposes.

① Boiler air piping
② Turbine and generator air piping
③ Common equipment air piping of unit

For supply of air to boilers and turbines, a supply master pipe should be arranged in a loop form on each floor. The piping should be divided in the respective floors as appropriate according to the amount of air consumed and piping route. (Refer to Figure 3-10-9)

(d) Headers and auxiliary receivers

a. The respective headers should be installed at the following positions. (Refer to Figure 3-10-10)

① Supply source header: To be installed at the air filter outlet piping.

② Supply air header: To be installed at the local instrument boards, local junction boxes, etc.

③ Control terminal header: To be installed on actuator of drive or valve units and so forth (in case the control piping has two or more cores)

b. Auxiliary receivers

In case the air pressure is estimated to drop because of excessive length of the supply master pipe from the supply header as well as due to rapid increase of air consumption in a particular area, an auxiliary receiver should be installed in the middle of such an air source system.

(e) Bypass valves

Bypass valves should be provided for the following equipment:

① Air dehumidifiers (dryers)
② Air filters
③ Pressure regulator valves for back-up of station service air, and drain separators

(f) Air pressure reducers

Instead of installing air pressure reducers by gathering supply headers into a group and gathering supply master pipes into another, etc., an air pressure reducer (with filter) should be installed on a per-controller basis and per-control terminal basis.

Should it be inevitable to install air pressure reducers by forming groups of headers and master pipes as mentioned above, such groups should not extend across more than one control system. [Specific example: Install one common pressure reducer (with filter) for the controller and transmitter of the steam pressure control system, and another common pressure reducer (with filter) for the diaphragm valves in the soot blower pressure control system, etc.].

(2) Piping Materials

(a) Instrument control air compressor - Air dehumidifier inlet:

Gas pipe (black), SGP (B)

(b) Air dehumidifier inlet - Air filter inlet:

Gas pipe (white), SGP (W)

The air dehumidifier inlet/outlet should be terminated with a flange.

(c) Air filter inlet valve - Local instrument board and junction box inlet (supply master pipe):

Seamless non-phosphorus deoxidised copper pipe
(thickness: 2 mm)

(d) Control air connector pipe with other unit:

Gas pipe (white), SGP (W)

(e) Air filter bypass pipe:

Seamless non-phosphorus deoxidised copper pipe
(thickness: 2 mm)

(f) Piping related to controllers downstream of local instrument boards and junction boxes

a. Control copper pipe (single, 2-, 3- and 4-cores), without communication cable
b. Raw pipe: Seamless non-phosphorus deoxidised copper pipe

(g) Header and so forth

Same material as that for supply master pipe

(h) Other

Although the standard piping materials are as listed in the present Item (2), the materials to be applied at the time of extension or modification work shall be selected taking into account co-ordination with existing equipment, ambient conditions in the case of outdoor installation including the design standards of NEK.

(3) Dimensions of Piping

In principle, the dimensions of piping should be determined according to the amount of control air consumed. In the case of the supply air master pipes, supply air pipes and control air piping downstream of the air dehumidifier outlet, however, the dimensions should be determined according to the following criteria:

(a) Air dehumidifier outlet - Master pipe on each floor (Refer to Figure 3-10-9)
2B (or over)

(b) Master pipe outlet on each floor - Local instrument boards and junction boxes:
3/4B, 1B, 1-1/2B

(c) Local instrument panel and junction box - Piping for controllers:

- 6.0^{OD} x 1.0 t
- 10.0^{OD} x 1.0 t
- 12.0^{OD} x 1.0 t

(d) Supply header: 3B

(e) Control air connector pipe with other unit:
2-1/2 B

6.13.2 Station Service Air Source Equipment

The station service air source equipment should be installed independently from the instrument control air source equipment to supply compressed air for multiple applications inside the power plant including construction and installation works and maintenance cleaning operations. Piping will be distributed in the power plant to make this air available in several points.

(a) Equipment configuration of station service air piping system

- Station service air compressors
- Station service air after-filters
- Station service air receivers
- Supply headers, branch valves
- Piping and valves

(b) Backup system

a. Backup system connector pipe for use in case of drop in the instrument control air pressure (including automatic valves)

b. Station service air system connector pipes to other power units.

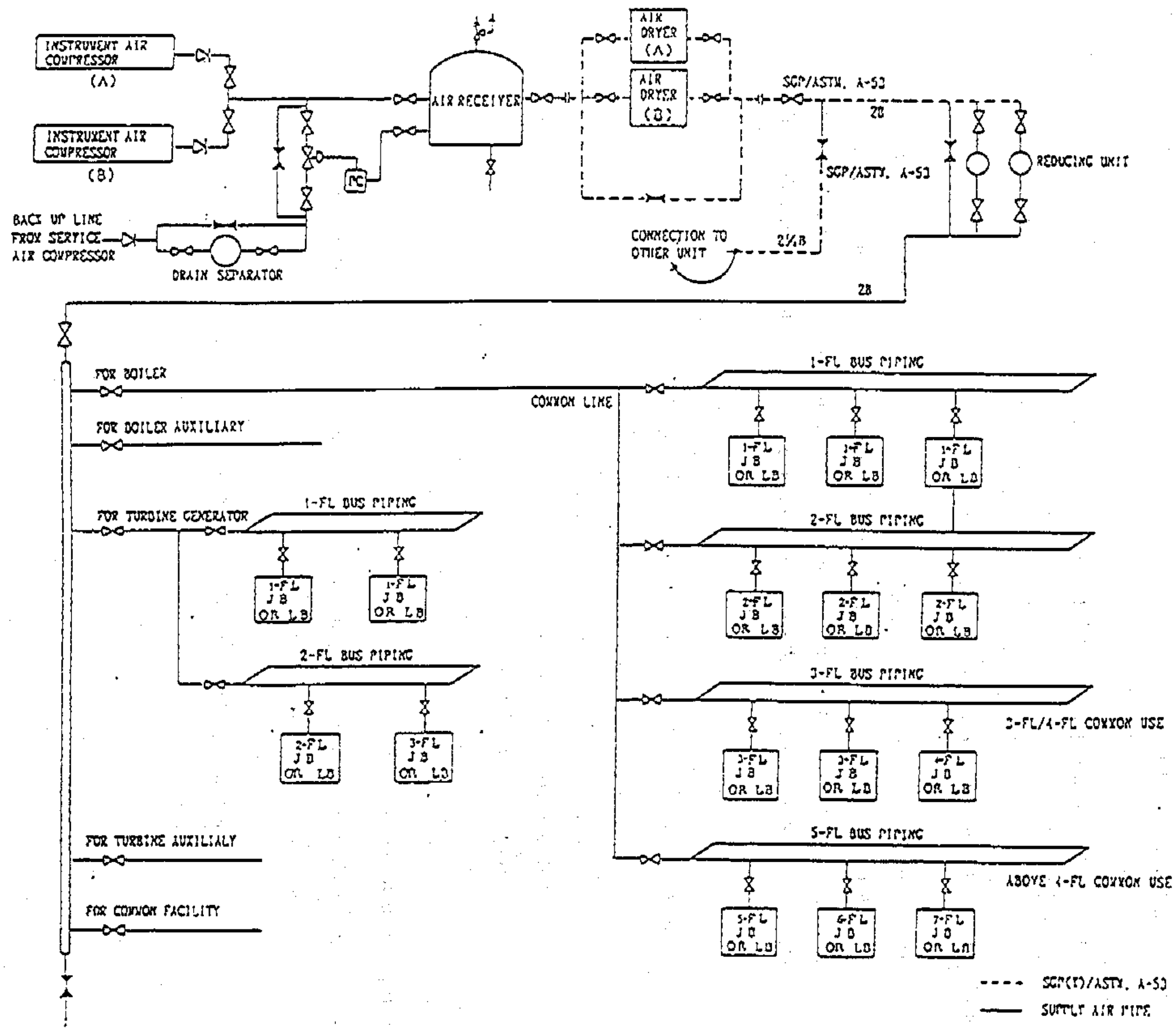


Figure 6-13-1 INSTRUMENT AIR PIPING LINE

6.14 Storage and Transportation Facilities of Fuel and Limestone

6.14.1 Coal Facility

(1) Coal Storage Facility

(a) Study parameters

1) The former No. 1 ash disposal yard (already leveled) shall be used for storage coal instead of the existing coal storage yard.

2) Coal shall be received via freight cars.

3) Currently coal is received as follows:

a. There are 3 systems in the reception facility, one of which is scheduled to be removed.
b. The capacity of a freight car is 55 tons (coal). 1 freight unit is 7 to 10 cars.
c. Coal is received 8 to 10 times a day (each takes 1 hour). We have a number of personnel enough to receive coal 12 hours a day.
One receiving operation takes 15 minutes with 10 cars.
d. The size of coal shall be 40 cm square or less, which is the size of the hopper screen.

4) Clay (so-called black clay) is included in coal received necessarily due to coal seam structure, which may in rare case interfere with transportation and burning of coal under specific weather condition, the following operations will be required:

a. Remove black clay lumps from coal as far as possible by visual inspection when coal freight is received.
b. Sort out sizes of coal after crushed and separate uncrushable lumps before storage.
c. Coal shall be stored in structure protected from rain or snow.

5) Responsibilities of the power plant and the coal company shall change at the time coal is received.

6) Minimum coal storage: 23 days
The minimum amount of storage shall be the least amount required for days as specified by the Bulgarian standard.

7) Coal consumption of reconstructed plant: 840 t/h (420 t/h × 2 units)
20,200 t/h (≒ 840 t/h × 24 h)

(b) Study result

1) Design specifications based on the above are as follows:

a. The existing railroad track to be branched out and a coal receiving area shall be set up close to the new coal storage facility.

b. The capacity of the coal receiving area will be limited to one fleet of 10 freight cars due to time required for weighing in each load of coal. Each reception system shall be 2 systems of 2 trains based on coal consumption per day and the number of personnel available.

The 2 trains of car loads shall be 1,100 tons (10 cars × 55 t/car × 2 trains) which will take 40 minutes (including receiving and discharging at a storage place).

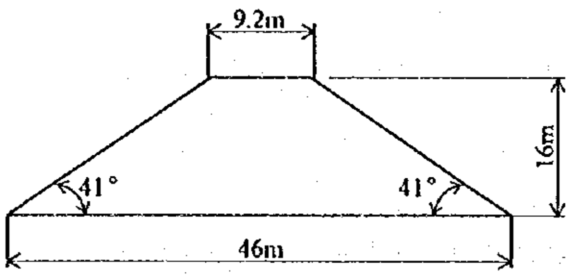
- Number of receptions per day: 19 times (about 20,200 t/d ÷ 1,100 t/train)
- Total coal reception hours per day: 13 hour ≒(19 times) × (40 minutes) ÷ (60 minutes)]

c. The capacity of coal reception system shall be enough to transport 2 system carloads in 30 minutes.

- Capacity: 2,200t/h [≒ (10 cars) × (55 t/car) × (2 trains) ÷ (0.5 hour)]
- Each capacity will be 1,100 t/h with 2 receiving reclaimers.

d. The capacity and system of the coal storage yard are as follows:

- Amount of coal stored: 465,000 tons [23 days: (20,200 t/d) × (23d)]
- Storage system: Natural piling
- Piling rate: 0.85 Coal mass ratio: 0.95
- Geometry of cross section



$\therefore A = 441.6\ m^2$

- Total length of pile

$$L = (20{,}200\ t/d) \times (23d) \div (441.6m^2) \div (0.95) \div (0.85) \fallingdotseq 1{,}303m$$

Therefore, the pile configuration is 4-row (4 x 330m/pile) due to the shape of the land.

e. The following facilities are provided for clay:

- Screens and crushers (400 to 150 mm in diameter) in receiving system.
- A roof is placed on the storage area (no side walls).

2) Outline of major facilities based on the above design specifications are as follows:

The flowchart is shown in Figure 6-14-1-1.

a. Receiving facility

- Coal car station: Coal is dropped from 10 cars (55t/car) × 2 trains.

• Receiving reclaimer:	(Type)	Bucket wheel type
	(Capacity)	1,100 t/h × 2 sets
	(Wheel diameter)	6,000mm
• Receiving conveyor:	(Type)	Belt conveyor (BC-1A,1B)
	(Capacity)	1,100 t/h × 2 systems
	(Belt width)	1,200 mm
• Transfer conveyor:	(Type)	Belt conveyor (BC-2,3,4,5)
	(Capacity)	2,200t/h
	(Belt width)	1,600mm

b. Coal storage facility

• Building:	Half-roofed (roof only)	
• Tripper:	(Capacity)	2,200t/h × 5 sets
• Tripper conveyor:	(Type)	Belt conveyor (BC-6A, 6B, 6C, 6D)
	(Capacity)	2,200t/h × 4 systems
	(Belt width)	1,600mm

c. Other auxiliary facilities

• Screen:	(Type)	Grid-shaft type
	(Capacity)	2,200t/h × 1 set
• Crusher:	(Type)	Hammer type
	(Capacity)	400 t/h × 1 set
• Magnetic separator:	(Type)	Suspended type (1,600mm)
• Sampling device:	(Type)	Spoon sampler

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

1) Since coal (465,000 tons) and heavy facilities such as receiving and reclaining facilities will be set up in the former coal ash disposal area, possible subsiding of the land must be considered. The investigation of the land structure and land reforming may be required depending on geological and land features.

2) Under the present plan (4 piles, 23 days) there will be no problems for the storage area. But we will have problems in the operation of car transportation such as number of cars in 2 trains (20 cars), number of receiving (19 times/day), hours required for transportation (13 hours or longer) and receiving coal burned in the existing plant.
Therefore, the coal company, limestone suppliers and power plant must make a detailed plan for car operation and to establish a coordination and communication system between the three.

(2) Coal Transporting Facilities

(a) Study parameters

1) A system between the new coal storage yard and reconstructed coal bunker.
2) Providing a crusher in the system that is used to crush coal into 40m/m in diameter or smaller lumps that are to be thrown into the coal bunker.
3) Coal transfer time shall be 24 hours the same as the present rate and the capacity of the bunker shall be the amount of coal burnt in 6 hours.
4) Belt conveyors shall be used for transporting coal.
5) Coal consumption of reconstructed plant: 840 t/h (420t/h × 2 units).

(b) Study result

1) Design specifications based on the above are as follows:

a. The capacity of the discharge reclaimer shall be one unit (420 t/h) per car
420 t/h × 4 sets
b. Coal are discharged 24 hours continuously; 2 units/2 systems (1 system reserved).
420 t/h × 2 systems

2) The outline of major facilities based on the above design specifications shall be as follows:
The flowchart is shown in Figure 6-14-1-1.

a. Reclaining facilities

- Reclaimer

Type	:	Portable scraper
Capacity	:	420t/h × 4 sets

- Recclaining conveyor

Type	:	Belt conveyor (BC-7A, 7B, 7C, 7D)
Capacity	:	420 t/h × 4 systems
Belt width	:	800mm

b. Transport facilities

- Transport conveyor

Type)	:	Belt conveyor (BC-8A, 8B, 9A, 9B)
Capacity	:	840 t/h × 2 systems
Belt width	:	1,000mm

- Bunker conveyor

Type	:	Belt conveyor (BC-10A, 10B)
Capacity	:	840 t/h × 2 systems
Belt width	:	1,200mm

- Scraper

Type	:	Belt lifting
Size	:	1,200mm

c. Other auxiliary facilities

- Screen

Type	:	Grid-shaft type
Capacity	:	840 t/h × 1 set

- Primary crusher

Type	:	Hammer type
Capacity	:	400 t/h × 1 set

- Secondary crusher

Type	:	Hammer
Capacity	:	200 t/h × 1 set

- Magnetic separator

  Type : Suspended (1,000mm)

- Sampling device

  Type : Cutter sampler

- Recycle conveyor

  Type : Chain conveyor

  Capacity : 20 t/h × 2 sets

6.14.2 Limestone Facilities

(1) Study Parameters

(a) The existing coal receiving system that were scheduled to be removed shall be used for receiving limestone via freight cars.
The car-load capacity shall be one 10-car unit (55 tons/car).

(b) The diameter of limestone to be received shall be 50 m/m or smaller.

(c) Minimum limestone storage: 23 days (same as coal)

(d) Time required to transport limestone to the bunker shall be 24 hours same as in the case of coal.

(e) Belt conveyors are used for transfer

(f) Limestone consumption of reconstructed plant: 180 t/h (90t/h × 2 units)
4,400 t/d (≒ 180t/h x 24 h)

(2) Study Result

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

1) The existing coal receiving track will be used and the storage area set up adjacent to the new coal storage yard.

2) One unit of carload shall be 550 tons (10 cars × 55ton/car) based on limestone consumption per day with time required for handling one carload shall be 40 minutes (includes incoming and outgoing limestone).

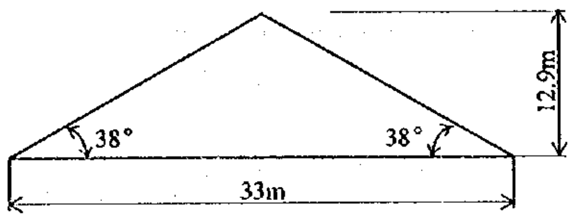
   - Number of receptions per day: 8 times [≒ (4,400 t/d) ÷ (10 cars) ÷ (55t/car)
   - Total limestone reception hours per day: 6 hours [≒ (8 times) × (40 minutes) ÷ (60 minutes)]

3) The capacity of receiving limestone shall be the amount transferable in 8 hours per day.

- Capacity : 540 t/h [= (180 t/h) × (24h) ÷ (8h)]

4) Storage yard

- Amount to be stored: 100,000 tons [(23 days ≒ (180 t/h) × (24h) × (23d)]
- Storage method: Natural piling
  Limestones shall be stored indoors.
- Mass ratio of limestone: 1.6 Piling rate: 0.85
- Length of pile:
  $L = (180\ t/h) \times (24h) \times (23d) \div (212m^2) \div (1.6) \div (0.85) \fallingdotseq 345m$
- Shape of cross section



$\therefore A = 212\ m^2$

5) The capacity of limestone reclaining system shall be the amount dischargeable in 24 hours continuously with 2 units/2 systems (one system reserved).

: 180 t/h x 2 systems

(b) Outline of major facilities based on the above design specifications are as follows:

The flowchart is shown in Figure 6-14-2-1.

1) Receiving facility

Limestone car station: Existing coal receiving area that were scheduled to be removed shall be used for receiving limestone.

- Rotary plow

Type	:	Plow-rotating
Capacity	:	540 t/h x 1 set
Diameter of plow	:	2.500mm

- Receiving conveyor

Type	:	Belt conveyor (LBC-1)
Capacity	:	540 t/h

Belt width : 650mm

- Transfer conveyor
  - Type : Belt conveyor (LBC-2,3)
  - Capacity : 540t/h
  - Belt width : 650mm

- Magnetic separator
  - Type : Suspended (650mm)

2) Storage facility

- Building : Indoor steel framed building

- Tripper
  - Capacity : 540 t/h x 1

- Tripper conveyor
  - Type : Belt conveyor (LBC-4)
  - Capacity : 540 t/h
  - Belt width : 650mm

3) Reclaining facility

- Reclaimer
  - Type : Portable scraper
  - Capacity : 180 t/h x 1 set

- Reclaining conveyor
  - Type : Belt conveyor (LBC-5A, 5B)
  - Capacity : 180 t/h x 2 systems
  - Belt width : 500mm

4) Transport facility

- Transport conveyor
  - Type : Belt conveyor (LBC-6A, 6B)
  - Capacity : 180 t/h x 2 systems
  - Belt width : 500mm

- Bunker conveyor

Type	:	Belt conveyor (LBC-7A, 7B)
Capacity	:	180 t/h x 2 systems
Belt width	:	650mm

- Scraper

Type	:	Belt lifting
Size	:	650mm

- Magnetic separator

Type	:	Suspended (500mm)

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

(a) Since heavy facilities such as receiving and reclaining for handling limestone (100,000 tons) will be set up in the former coal ash disposal area, possible subsiding of the land must be considered. The investigation of the land structure and land reforming may be required depending on the geological and land features.

(b) Under the present plan (1 pile, 23 days) there will be no problems for the storage area. But we must consider the following points since car operation is expected to become complicated as in the case of coal reception.

1) Careful plan for car operation
2) Coal company, limestone suppliers and power plant must discuss and establish a coordinating and communication system between the three.
3) Increase safety personnel for complicated car operations.

6.14.3 Heavy Oil and LPG Equipment

(1) Study Parameters

(a) The situation of equipment currently provided is as follows.

1) Although there are heavy oil equipment (reception, storage, supply) and diesel oil equipment (reception, storage, supply), there is no LPG equipment.

2) A supplier for this plant is Burgas/chemical complex (Nefthin: imported from Arab). Oil is received through railway transportation. The reception system is as follows.

- Heavy oil: 5-car freight unit (50t/car) → existing pump → tank (1,000m³+250m³ x 4)
  → new pump → tank (2,000m³ x 2)
- Diesel oil: 5-car freight unit (50t/car) → pump → tank (250m³ x 4)

3) The operation of existing heavy oil combustion system is as follows.

- The heavy oil system is always warmed up by continuous running of the pump.
- The pipe capacity was conventionally enough for supply to #1 - #10 boilers.
- Existing burner specification: 4t/h/unit x 4 units/1 boiler
  30 - 32 ton is consumed for 3.5 - 4.0 hours at startup

4) New heavy oil equipment comprises tank (2,000m³x2), receiving/supply pumps, heater and strainer, etc. and new supply pipe is connected to existing burner pipe (90t/h).

- New pump specification → Receiving pump: 119t/h, 55kW x 2
  Supply pump: 58t/h, 35bar, 58kW x 2
- Figure 6-14-3-1 shows an outline system of new heavy oil reception/discharge.
- Table 6-14-3-1 shows properties of heavy oil.

(b) Expected use amounts of heavy oil and LPG (for igniting heavy oil) to be used for start and stop of a fluidized bed combustion boiler are calculated under the following condition.

- A single unit is shut down per year for periodic inspection.
- A single unit is shut down twice a year for other reason than scheduled shutdown, such as accidents.
- Two units are not started at the same time.
- The use amount for cold start and shutdown serves as a basis for this calculation.

(2) Study Result

(a) Design specifications are assumed as follows according to the above mentioned study parameters.

1) The expected yearly consumption amount is as follows.

[Heavy oil] Cold start and stop (1 time) Consumption amount (1 unit)

Startup = air-heating furnace burner: 75t = 10t/h x 7.5h
furnace burner: 25t = 20t/h x 1.25h

Shutdown = furnace burner: 10t = 20t/h x 0.5h

∴ Expected yearly consumption amount (2 units) = 660t/y [680m^3/y]

(75 + 25 + 10) t/h x (1+2) time/Y = 330 t/y/1 unit

330 t/Y ÷ 0.986 ≒ 340 m^3/Y/1 unit

[LPG] Ignition burner capacity is assumed to be 4% heavy oil burner capacity.

330 t/ x 0.04 = 13.2 t/Y (Heavy oil basis)

13.2 t/ x 9,525 kcal/t ÷ 11.84 kcal/t ≒ 11 t/Y (LPG basis)

11 t/Y ÷ 0.8 ≒ 14 m^3/Y (LPG basis)

However, because the ignition timings of the ignition burner and heavy oil burner are not the same, the use amount is assumed to be the same ratio of the ignition timing.

Heavy oil: 7.5 + 1.25 = 8.75 hr (525 min), LPG: 3min/burner

∴ Expected yearly consumption amount (2 units) = 1.0 m^3/Y

14m^3/y x 3min/burner x 6 burner ÷ 525 min ≒ 0.5m^3/y/1 unit

2) For the reason of yearly heavy oil consumption amount (680m^3/y), new installed heavy equipment will be used and new LPG equipment will be constructed near each boiler building.

A legally assembly bottles is specified so that nonflammable walls are provided, they are contained in nonflammable cabinet and the total capacity is less than 1.0kℓ.

3) LPG is received by means of bottle (80ℓ). The expected yearly consumption amount is 14 bottles (2 units).

[0.5 kℓ ÷ 80ℓ/bottle ≒ 7 bottles/1 unit → 14 bottles/2 units]

The purchase cost is yearly 20,600leva/2 units.

[80ℓ/bottle x 14 bottles x 0.8 x 23leva/kg = 20,600leva/2 units]

(b) The outline of major equipments based on the above mentioned design specification is as follows.

1) Heavy oil

a. Receiving equipment

Substitution by new equipment [5-car freight unit (50t/car) → receiving pump (119t/h x 2 units) → tank]

b. Storage equipment

Substitution by new equipment [2,000m3 x 2 units]

c. Supply equipment
Substitution by new equipment [supply pump (58t/h x 2) --> heater x 2 --> each boiler]

2) LPG

a. Receiving equipment
Bottles (80ℓ) are carried in by trucks.

b. Storage equipment
Bottles (7) are stored in a nonflammable cabinet near nonflammable wall of each boiler building.

c. Supply equipment
Following equipment is installed within a nonflammable cabinet of each unit.
Pressure adjusting valves, safety valves, pressure gauge, etc.

Table 6-14-3-1 Heavy Oil Properties

Item		Bulgarian Standard	Acceptable Properties
Calorific value (HHV)	MJ/kg	39.8	39.88
	(Kcal/kg)	(9,506)	(9,525)
Kenematics 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

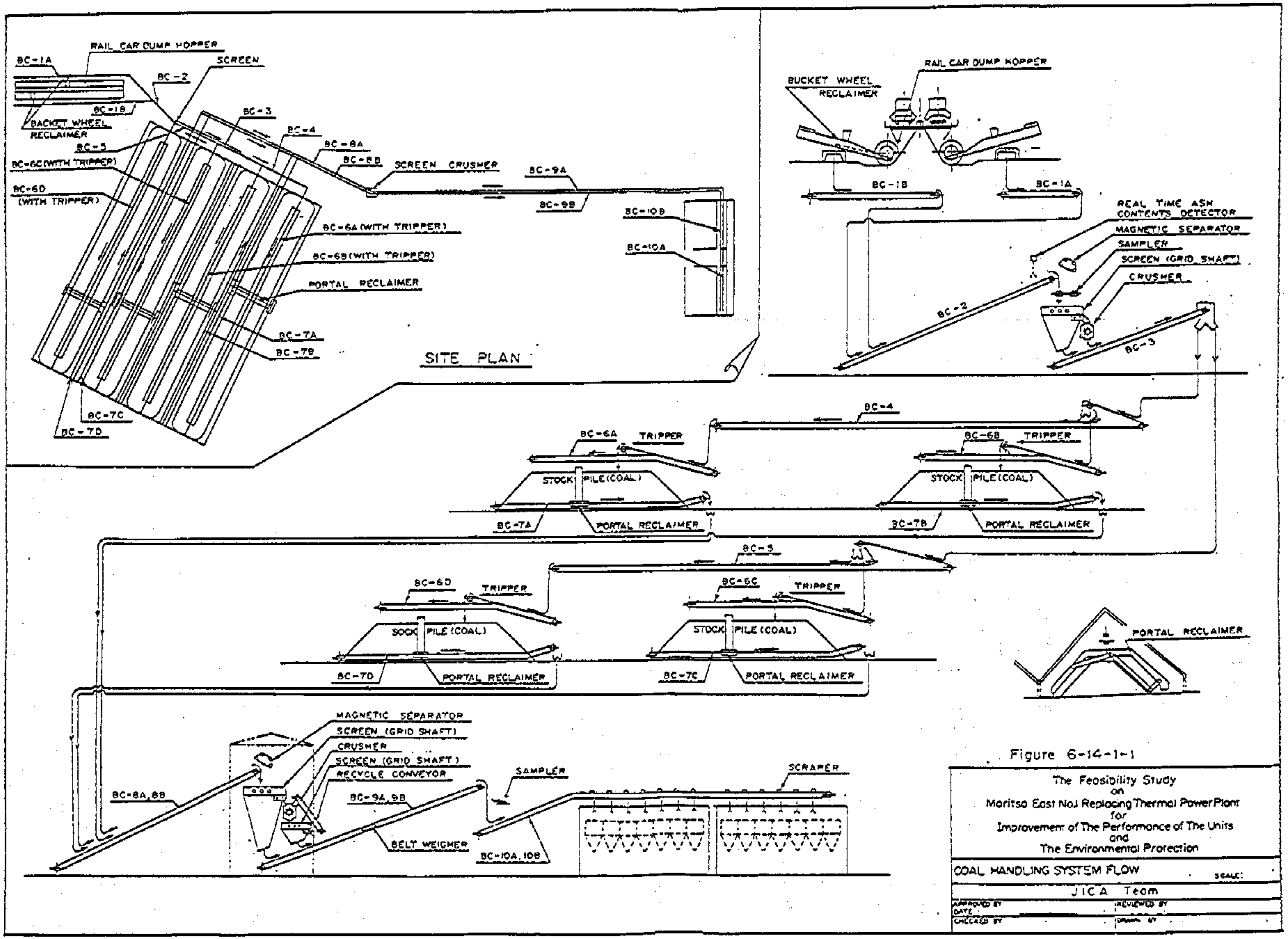


Figure 6-14-1-1

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

COAL HANDLING SYSTEM FLOW — SCALE:

JICA Team

APPROVED BY — REVIEWED BY
DATE
CHECKED BY — DRAWN BY

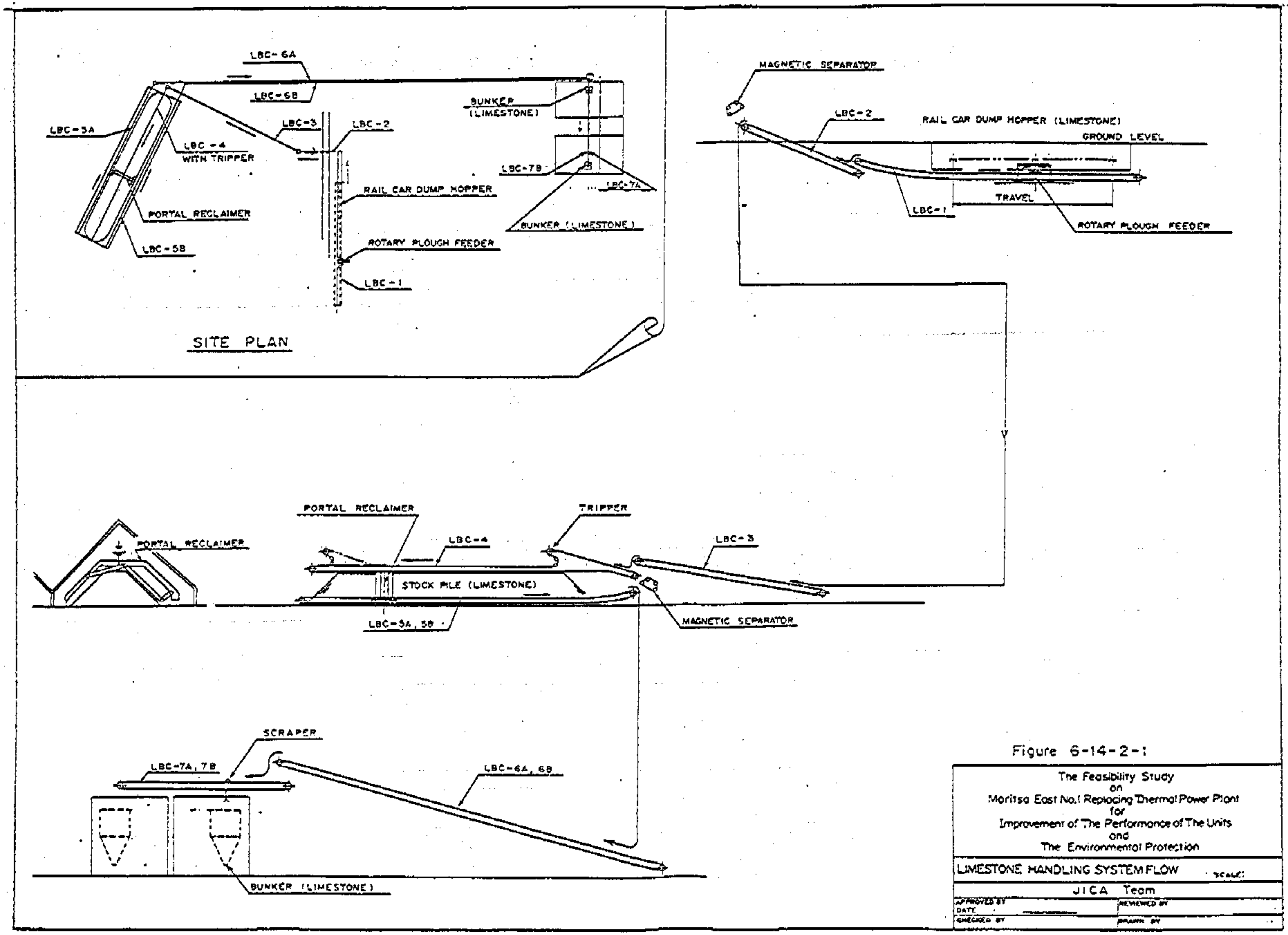


Figure 6-14-2-1

The Feasibility Study on Moritsa East No.1 Replacing Thermal Power Plant for Improvement of The Performance of The Units and The Environmental Protection
LIMESTONE HANDLING SYSTEM FLOW SCALE:
JICA Team
APPROVED BY / DATE / CHECKED BY / REVIEWED BY / DRAWN BY

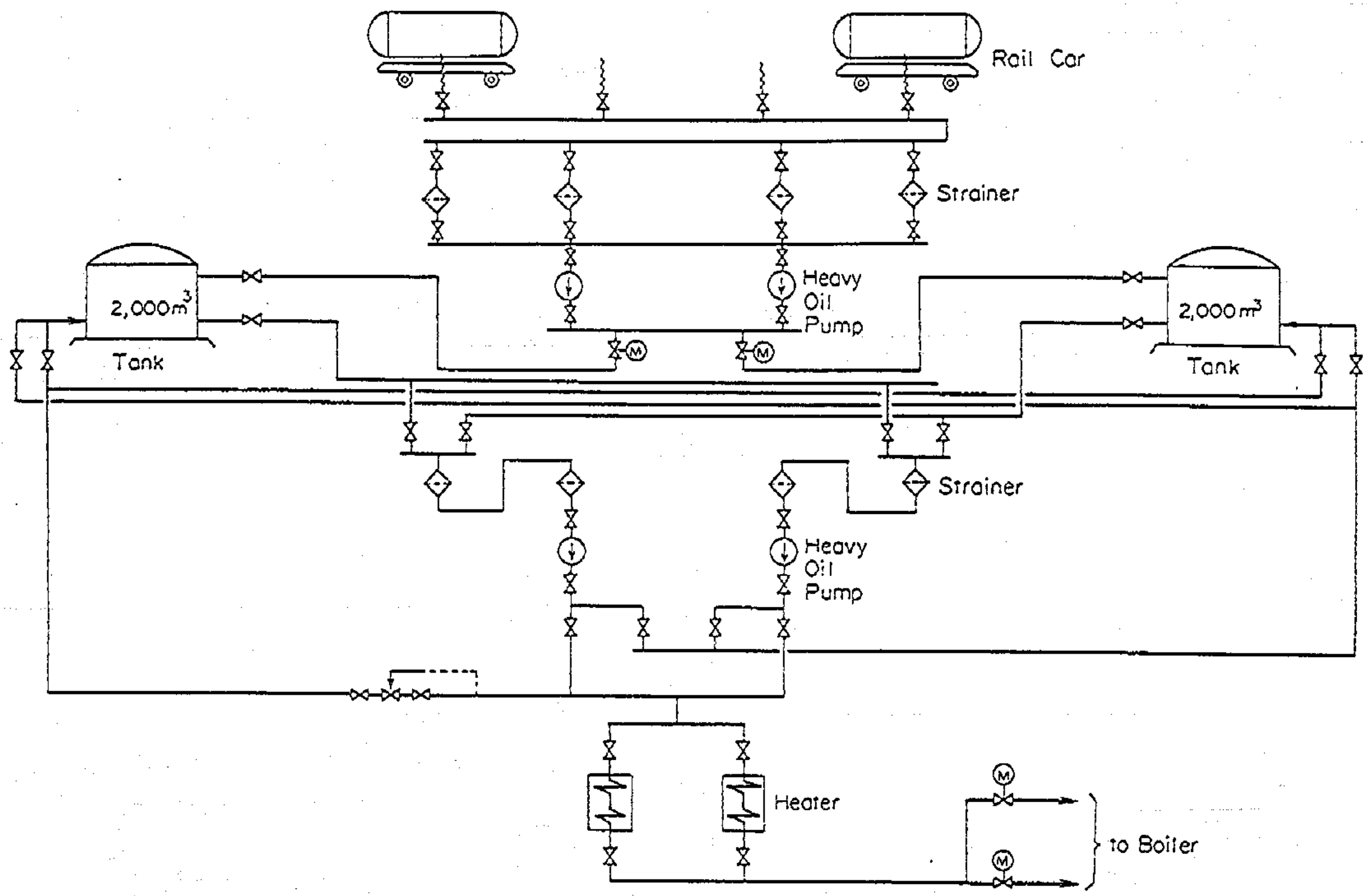


Figure 6-14-3-1 System of Heavy Oil Receiving and Discharging

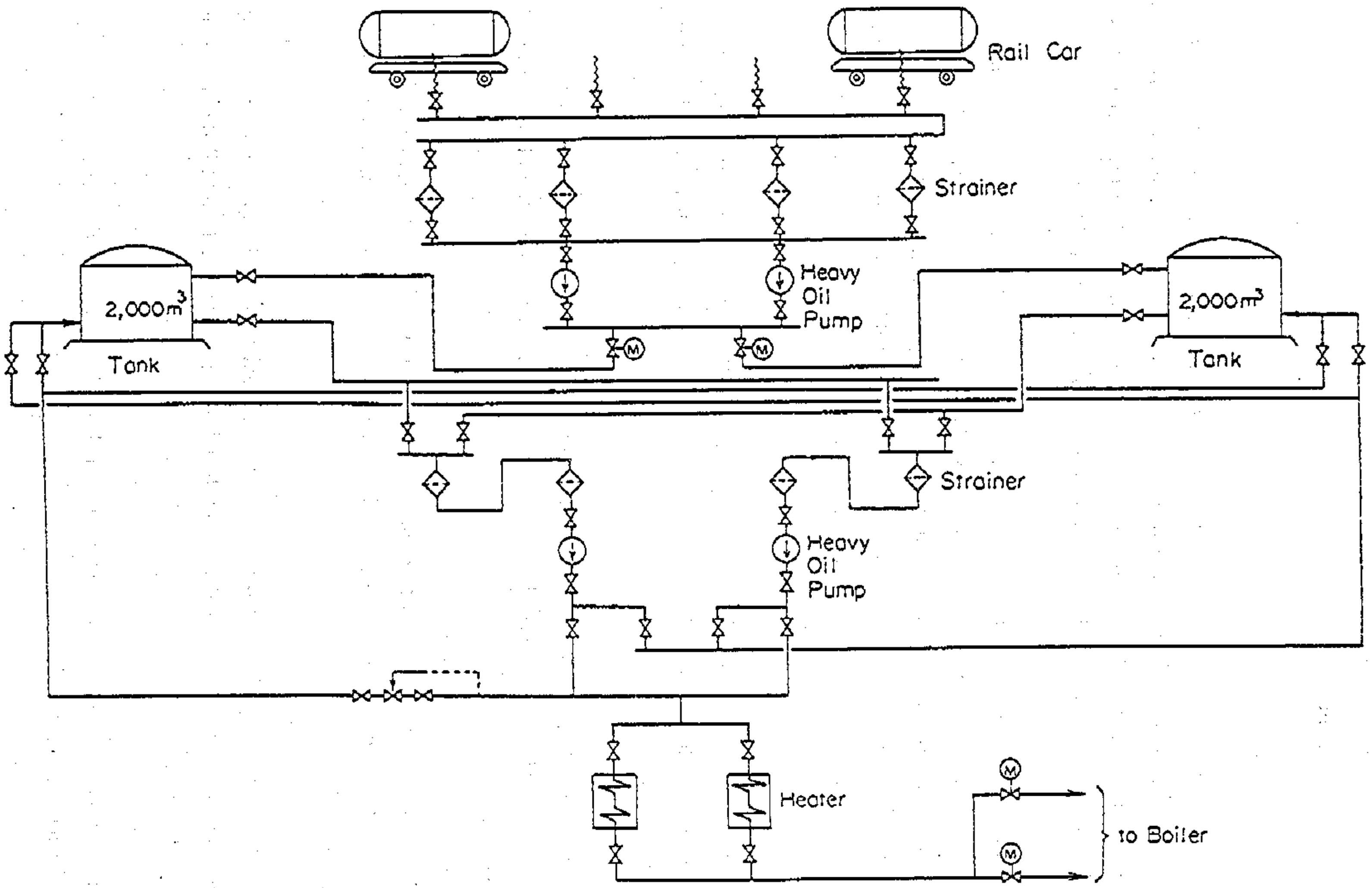


Figure 6-14-3-1 System of Heavy Oil Receiving and Discharging

6.15 Electrical & Control Equipment

6.15.1 Electrical Equipment

6.15.1.1 Power transformers

(1) Condition for study

(a) In addition to the main transformer and station service transformer installed for each unit, one set of starting transformer (auxiliary transformer) is required as a transformer common to the power units. The starting transformer will be installed at the time of constructing unit R-1, and its appropriate capacity is considered to be roughly 40 MVA.

(b) The rated capacity of the main transformer should be equal to that of the generators. In case the station service transformer is faulty, the station service power should be supplied from the starting transformer to enable the generator output to be transmitted.
The rated capacity of the station service transformer should be determined according to the required station service load capacity, power factor, station service ratio and utilisation factor.

(c) A starting transformer will be shared by power units R-1 and R-2 to step down the voltage from the switchyard bus and supply power to the station service circuitry during the start-up and shutdown of the units.

During normal operation of the units, the starting transformer should supply power to the common loads in the power plant and be in standby for backup in case of trouble in the station service transformers.

Therefore, the maximum rated capacity of the starting transformer should be sufficient to supply power to the common loads in the power plant and station service load of a single power unit.

(d) Since the actual load is much smaller than the maximum rated capacity of the starting transformer, however, the rated capacity should be duplicated and the oil-filled self-cooling type be adopted for it.

The rated capacity of the starting transformer should be enough for time-differential start-up of two power units.

(e) Protective relay

In order that a trouble in transformer due to malfunction or operation failure of the protective relay does not progress to any serious trouble, it is recommended to duplicate the ratio (percentage) differential relays and its current transformers (CT) in the case of 220 kV or higher voltage transformers.

(2) Design of disaster preventive countermeasures of transformers

The basic requirements for design of countermeasures for protecting the oil-filled transformers of power plant (e.g. main, starting, station service, local and other transformers) against disaster are as described below:

(a) Basic policy of design

Any oil leak should be limited to as small a range as possible, and by no means such leak oil be flown out to any river or other areas outside the compound of power plant. Should any fire accident occur, the damage shall be limited to the relevant transformer, and spread of fire to any other adjacent transformer or building be avoided.

(b) Oil leak countermeasures

① To prevent dispersion of oil during operation of the pressure relief device of a transformer, an oil drain pipe shall be arranged up to roughly 30 cm above the surface gravel level and not above the transformer foundation.

② Around any transformer, gravel shall be laid with a depth of roughly 30 cm to absorb leak oil.

③ In the case of transformer containing a large amount of oil such as the main transformer, oil dike shall be provided around the transformer to prevent flow-out of oil to the surrounding area. At the same time, an underground tank for collecting leak oil shall be installed to collect oil inside the oil dike.

④ The height of oil dike shall be 0.5 m or over. However, a part of the dike, for example the front part shall be made a little lower so as to limit the position of overflow.
The oil dike shall be installed as apart as possible from the transformer body, and its capacity be not smaller than 50% of the amount of transformer oil.

⑤ One underground oil drain tank shall be used commonly for two or more transformers. In principle, the tank capacity shall be not smaller than 100% of the oil capacity of the largest-capacity transformer. A water discharge pump of manually operated type shall be provided for the underground tank.

⑥ The water from the water discharge pump shall be led to an oil separator tank.

(c) Fire-protection wall

In case more than one transformer is arranged adjacent to each other, a concrete wall for fire protection shall be provided between the transformers.

The position and height of the fire-protection wall shall be determined as per the design criteria of ENG so as to prevent spread of fire to any adjacent transformer.

(d) Fire extinguishing equipment

① Around any 220 kV or higher voltage transformer, a water spray fire extinguisher and an auxiliary hydrant shall be provided.

The water spray fire extinguisher shall cover the upper surface of transformer including its cooler, and the water spraying flow be not smaller than 8 - 10 litres per square metres per minute.

The extinguisher shall be capable of both remote direct operation and local manual operation.

② Around any 110 kV or lower voltage transformer, a hydrant and a portable dry chemical fire extinguisher shall be provided.

(e) Manhole within oil dike

Any manhole and so forth shall not be arranged within any oil dike.
Should it be inevitable to arrange a manhole, a countermeasure shall be taken to prevent entry of any leak oil into the manhole.

(3) Results of study

(a) Main transformer specifications

Type : Outdoor service, 3-phase, forced oil air cooling type

Capacity	:	275 MVA
Primary voltage	:	14.7 kV
Secondary voltage	:	220 kV
Connection system	:	Delta-star

(b) Station service transformer specifications

Type	:	Outdoor service, 3-phase, oil-filled air cooling type
Capacity	:	35 MVA
Primary voltage	:	14.7 kV
Secondary voltage	:	6.9 kV
Connection system	:	Delta-Delta

(c) Starting transformer specifications

Type	:	Outdoor service, 3-phase, oil-filled air cooling or self-cooling type
Capacity	:	40 MVA
Primary voltage	:	220 kV
Secondary voltage	:	6.9 kV
Connection system	:	Delta-Delta

(d) Excitation power transformer specifications

Type	:	Outdoor service, 3-phase, oil-filled self-cooling type
Capacity	:	Approx. 1.8 MVA
Primary voltage	:	14.7 kV
Secondary voltage	:	770 V
Connection system	:	Delta-Delta, with

6.15.1.2 Plant power circuit configurations

(1) Station service circuitry

(a) The station service circuitry adopts a unit system configuration which has been proven to be high in reliability.

At the time of the unit start-up, this circuitry receives power from the starting transformer connected to the switchyard bus, and after the generator has been synchronised to power system, it supplies station service power from the station service transformer connected to the generator circuit.

(b) The values of the station service circuit voltage of the ME-1 Power Plant shall be as follows:

High voltage circuit	:	6 kV
Low voltage circuit	:	400 V, 220 V, 110 V, and 110V and 220 V DC

The short-circuit capacity of the station service circuitry will be determined after detailed design based on the impedance of the starting and station service transformers, taking into account voltage drop and contribution of generator.

The load distribution of the station service circuitry will be determined at the time of detailed design based on the load capacity.

(c) The station service power equipment includes the high-voltage metallic clad switching gear, which is the switching equipment for the high-voltage circuitry (6 kV, 4 kV and 3 kV) composed of two groups; the common group supplying the common power for the power plant buildings and power for the common auxiliaries for all of the power generating equipment, and the station service group supplying power for the required auxiliaries for operating the power generating equipment.

The loads are as listed in the following.

a) High-voltage motors with capacity of 200 kW or more.
b) Power transformer for low-voltage motors with capacity below 200 kW.

(d) Power from the high-voltage metallic clad switching gear is supplied through the power transformer to the low-voltage switch equipment. The low-voltage switch equipment is classified into the 440 V power centre which handles power for auxiliaries in the capacity class of 75 kW to 1200 kW and te 440 V control centre which handles lower-capacity power than the above.

(e) A low-voltage (200 V or 100 V class) power distributor board will be installed to supply power to other equipment than auxiliaries, such as the lighting equipment, control equipment and working equipment. This power distributor board incorporates non-fuse circuit breakers.

(f) To run the existing units 3 and 4, the 6 kV station service power bus should be provided with a power line which is connected to the starting transformer circuitry through a circuit-breaker.

(2) Selection of motor

The specifications of motors should in principle be as listed below, and further detailed specifications be determined during detailed design by referring to the design criteria of ENG.

① General use AC motor

Capacity class (kW)	Voltage (V)	Insulation level	Location	Type	Space heater
≧200	6,600	Grade F or Grade B	Outdoor Indoor	Totally enclosed Protected	Required
75-<200	400	Grade F or Grade B	Outdoor Indoor	Totally enclosed Protected	Required
1-<75	400	Grade F or Grade B	Outdoor Indoor	Totally enclosed Protected	Not required
<1	220	Grade E	--	Totally enclosed	Not required

② AC motor for motor-operated valve

Capacity class (kW)	Voltage (V)	Insulation level	Location	Type	Space heater
>3.3	400	Grade F or B	---	Totally enclosed	Required
<3.3	220	Grade E			[To be mounted on gear box]

③ DC motor

Capacity class (kW)	Voltage (V)	Insulation level	Location	Type	Space heater
≧0.23 General use	110 or 220	Grade F or B	—	Totally enclosed	Not required
<0.23 Control use	110 or 220				

④ Starting characteristics

- In principle, the starting current of the induction motor should be within 650%of the rated current. For 3,000 kw or larger capacity induction motor, however, it may have to be reduced to roughly 100 - 500% of the rated current to restrict voltage drop at the time of start-up, and should be determined after careful review.

- The starting current of DC motor should be within 150-200% of the rated current by using a starter.

⑤ Accessories

- It is recommended to install a terminal box separately for the power circuit and space heater.

- Solderless terminals for connection of external cables should be provided for any motor.

- The earthing terminal should be of a clamping type, and the size be determined as per the design criteria of ENG.

- The space heater should have an enough capacity to keep the internal temperature of motor not higher than its dew point while not in service and so designed as to ensure easy inspection and replacement.

  The terminal voltage of space heater should be 220 V(AC).

- Bearing temperature
  A bearing thermometer and a computer monitoring element (RTD-Pt100 ohms) should be provided for any motor (high voltage and particularly important low voltage motors) having slide bearings [journal (sleeve) bearing, thrust bearing, etc.].

In principle, there is no need to monitor the bearing temperature in case of motors using roller bearings (ball bearing and roller bearing).

(3) Emergency power source equipment

(a) Conditions for study

① When the power supply to the station service system has totally been interrupted as a result of tripping of power unit due to a fault in the external line of transmission system or trouble in any unit, it is essential to ensure power supply to the auxiliaries required for safe shutdown of the relevant plant. Moreover, it is also essential to ensure power supply to the emergency lighting equipment, fire protection and safety guard equipment, battery charger and other important loads. Furthermore, power supply to the auxiliaries required to proceed to restarting operation immediately after restoration of the transmission system and/or power unit operation from trouble should also be ensured. For these purpose, one set of diesel power generator equipment and battery system (including charger) should be installed. The capacity of the generator equipment and battery systems will be determined from the rated capacity of the station service equipment to be designed later as well as from the transient capacity when such equipment is switched on.

② In view of the frequency of operation, equipment cost, space and other conditions, it would be more advantageous to install one set of diesel power generator equipment with a capacity equivalent to that of one unit as equipment common to two units instead of installing one set of equipment for every unit.

③ The emergency power source equipment should be connected to the emergency control centre so that the power for the normal operation of the plant is supplied from the station service power source and that the emergency power source can be supplied automatically from the emergency power source equipment at the time of total outage of the station service power source.

(b) Results of study

a) DC power supply equipment (storage batteries)

Type	:	Vent, clad instillation
Capacity	:	2,500 Ah/10 hrs.
Number of cells	:	14.7 kV
Voltage	:	6.9 kV
Quantity	:	1 set/2 units

b) Battery chargers

Type	:	Automatic voltage regulating, thrystor 3-phase, fullwave rectification
Voltage	:	220 V DC
Current	:	300 A
Quantity	:	1 set/2 unit

c) Emergency diesel power generator equipment

Drive motors	:	Diesel engines, directly coupled to each generator
Type	:	4-cycle, 1-cylinder
Output	:	7 ps
Rotation speed	:	1,000 rpm
Fuel	:	Heavy oil
Quantity	:	1 set/2 units

Generators

Type	:	Outdoor, 3-phase, automatic sync
Capacity	:	600 kVA
Voltage	:	480 V
Rotation speed	:	1,000 rpm
Power factor	:	0.85
Frequency	:	50 Hz

(4) Applicable rules, standards and criteria

IECPTE	:	European (EC) standards for electric products (EC)
PTE	:	Power plant maintenance and power transmission system rules (Bulgarian Energy Dept., 1980)
PUEV	:	Power facilities structure standards (Bulgarian Energy Dept., 1980)
PCTN	:	Fire extinguishing equipment construction engineering rule No. 2 (Bulgarian Internal and Construction Depts., 1994)
IP-44, 54	:	Fire extinguishing equipment construction engineering rule

Other

IEC publications

DIN standards

ISO standards

Reference should be made to the above rules and standards.

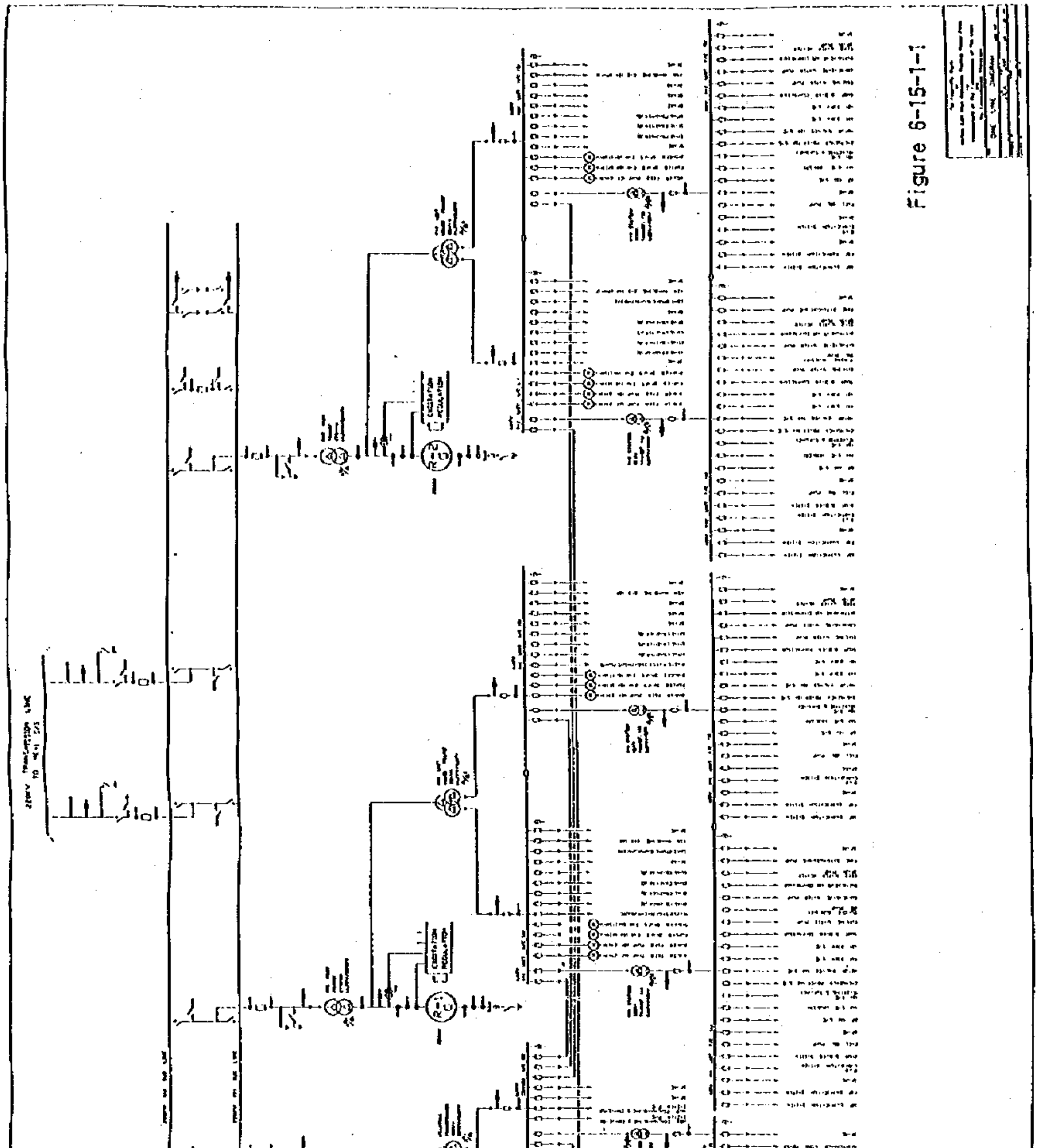


Figure 6-15-1-1

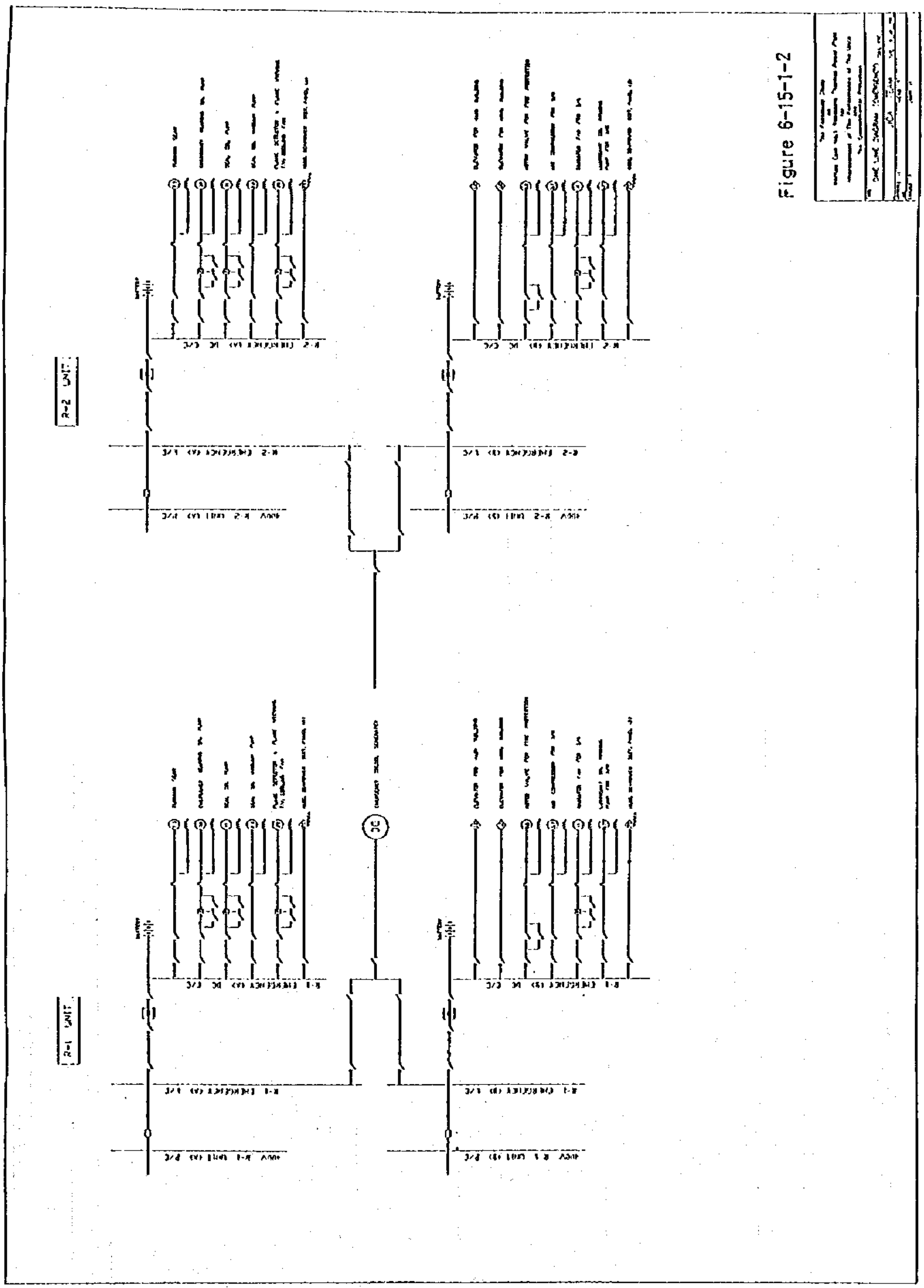
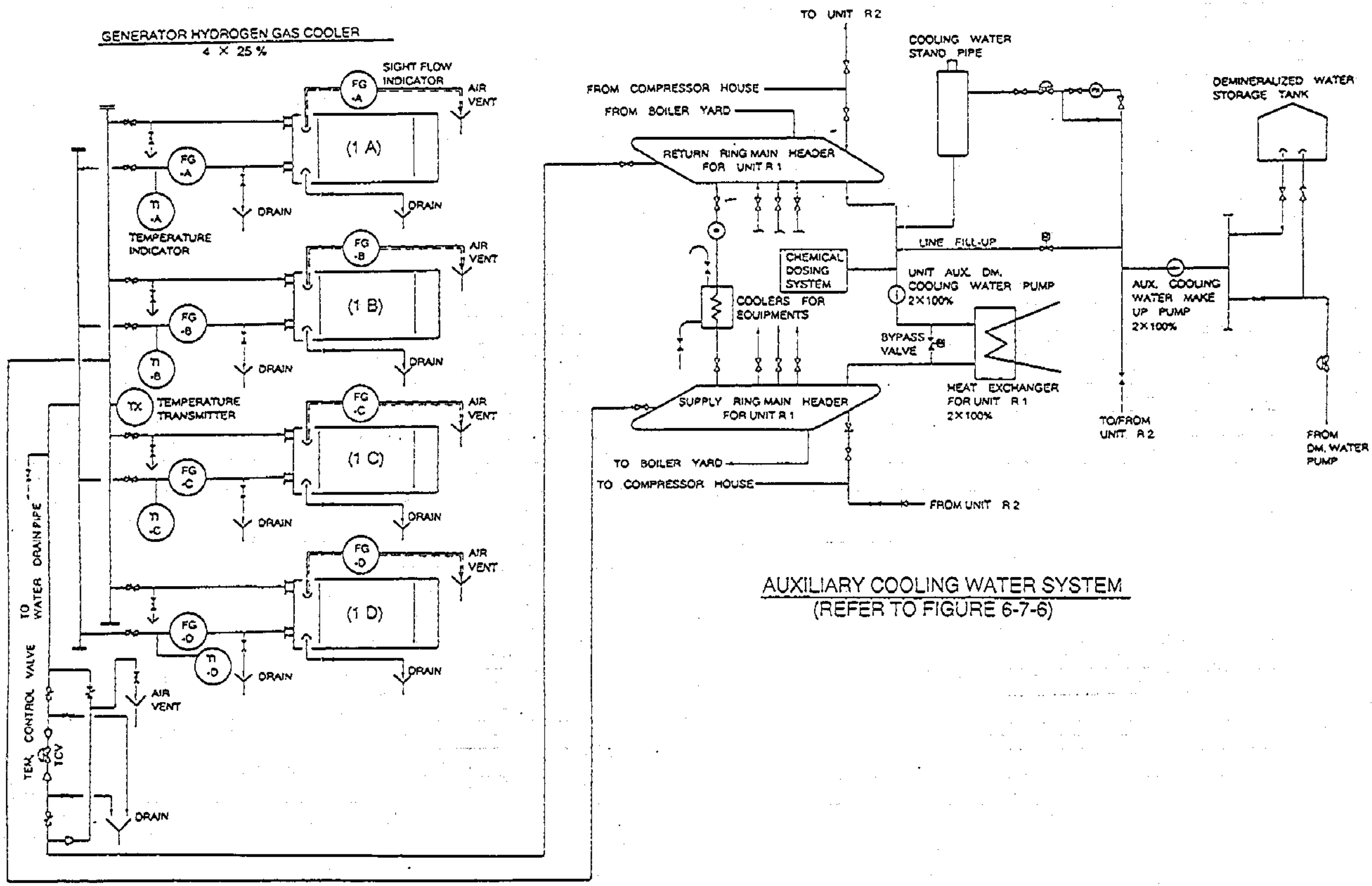


Figure 6-15-1-2



AUXILIARY COOLING WATER SYSTEM
(REFER TO FIGURE 6-7-6)

HYDROGEN COOLING WATER

Figure 6-15-1-3

6.15.2 Control Equipment

The use of a distributed control system (DCS) is effective for solving the tasks as described in the following.

(1) Necessity of DCS

(a) Reflecting a world-wide trend to reduce the dependence of thermal power plant upon oil, most of the newly installed thermal power units have been designed for coal or LNG (Liquefied Natural Gas) burning.

(b) To make effective utilisation of limited fuel resources, it has been demanded increasingly to realise high efficiency operation of thermal power plant, particularly in countries where the fuel costs are high.

(c) As thermal power plants are the most important power source for the electric power industry of Bulgaria, it is essential for the industry to make utmost efforts not only for assuring the reliability of electric power supply but also for promoting rational arrangement of operation staff, measures for preservation of environment, rationalisation of power plant operation and so forth.

(d) One of the most important tasks in managing the service life of thermal power plant for a stable operation over a long period of time is to reduce the thermal stress in boilers and turbines. Therefore, monitoring of stress is one of the important items.

(e) Since the delay in the response of the fuel system including the coal feeders and crushers is one of important problems of coal-fuelled thermal power plants, the boilers and turbines are required to follow up quickly and stably the load demands with less thermal stress and less consumption of service life.

(f) High reliability required for the plant can be achieved by improving the reliability of control equipment, the ease of plant maintenance, the reliability inherent to the digital technology and the reliability of the control system by means of redundancy as well as by improving the plant operability by diagnosis of performance monitoring.

(g) Easy monitoring and operation of plant can been made possible as a result of expansion in the automated control range, realisation of sophisticated control, improvement of man/machine interface, high speed processing of a large volume of data and graphic display of operating conditions.

(h) When such situations surrounding thermal power plants are taken into consideration, the technical tasks required for plant control system are diversified and highly sophisticated.

(2) Functions of DCS

The trend of sophistication and diversification of digital technology is presented in Figure 6-15-2-1. Backed up by the rapid progress of computer-related technology, the functions for tabulation of daily repoit, supervision on CRT and automated, direct computer control, which correspond to the conventional functions for recording, monitoring and control, have been expanded in response to the needs for further sophistication of plant operations. Particularly, the following three items are new functions which have not been available with the conventional power-unit-based DCS systems:

① Operation control through CRT (CRT operation)
② Operations support through application of intelligent engineering technology
③ Long term storage, retrieval and effective utilisation of plant operation data

DCS shall be provided with higher technical performance pertaining to response speed, control accuracy, availability (not less than 99.9%) and MTBF (mean time between failure) (not less than 30,000 hours), and able to function properly under the adverse and harsh conditions.

The capacity of processor's CPU (Central Processing Unit) shall be decided so that its load rate may be not more than 40%.

Frequency of information given to modulating processors and sequential processors shall be upgraded at least up to four (4) times per second and ten (10) times per second, respectively.

Maximum allowable duty cycle of processor module shall not exceed 250 milli-second (ms) at maximum loading to perform all assigned functions.

Modulating and sequence control loops demanding fast processing shall be capable of executing during the loop time of not more than 125 ms and 50 ms, respectively.

(3) Configuration of plant control system

Along with the progress of digital control technology, the reliability of plant and that of control system have been improved substantially at the same time. The digital technology has made it possible to realise a DCS (Distributed Control System) which controls the entire system by integrating the control functions distributed on a per-subsystem basis. The distributed control subsystems are connected through a network communication circuit and controlled as a single system. The system network (data highway) is duplicated, and the modules which are composed of microprocessors are also provided as duplicated systems.

(a) System configuration

The concept of the DCS system configuration is shown in Figure 6-15-2.

The distributed control functions for the respective units are as listed below. These are connected through a unit network:

a. Plant control (DPC: Dispatch Power Control, ALR: Automatic Load Regulator)
b. Boiler control (ABC: Automatic Boiler Con'.ol)
c. Turbine control (EHC: Electro-Hydraulic Control)
d. BFP control
e. Boiler and turbine sequencer control
f. Remote PIO (PIO: Process Input/Ou.put)

① The power unit-based DCS system undertakes integrated control of these functions, monitors the operating conditions and collects data for managing the performance of the unit.

② Through the man/machine interface, it is possible for operator to intervene with any part of the control system. The engineering work stations connected to the network can be used for modification of the DCS.

③ The central control room is equipped with the operator console, printer and backup console. By operating the consoles, the operator carries out operation of the power plant while keeping communication with the DCS.

④ The operating conditions of the plant are displayed on a monitor screen so that all of the operators can recognise the plant status. The information displayed on the screen includes the heat balance chart, flow chart containing the operation status data and other graphics stored in the system. Moreover, the screen of industrial monitor television can also be superimposed.

⑤ The backup console is provided for the case of trouble in the unit DCS and/or man/machine interface. The unit DCS of each power unit is connected to the power plant network. Moreover, the common equipment control systems which are installed independently in remote places to treat coal, limestone, ash and water and the plant management monitor system are also integrated into the plant network.

⑥ The cabinet housing the DCS system, programmable controller (sequencer), input/output converter and other devices should be installed in a dedicated, air-conditioned room. At the same time, an environmental protective measure should be taken to prevent penetration of dust and other foreign matter in this room.

⑦ Fail-safe, continuous operation of the power plant should be assured even in the case where the DCS control system has got in trouble. In addition, backup switches should be provided on the bench board to enable start-up and shutdown operations of the respective auxiliaries, dampers and control valves independently from the DCS system condition.

⑧ The central control room is designed based on the same concept as the ME-2 and ME-3 Thermal Power Plants. It should be equipped with the control bench board with the centralised control, operation and monitoring capabilities of two power units and an upright control panel, and the monitoring, start-up and shutdown switches, recorders, indicators and alarm display for boilers, turbines, generator and their auxiliaries should also be arranged on these board and panel. The shift chief engineer's desk should also be located in the central control room so as to improve the efficiency of the integrated management of the overall plant.

⑨ In addition, the auxiliary panels of instruments related to soot blower, disaster prevention, fire extinction and environmental protection should also be arranged in the control room.

Furthermore, centralised plant monitoring functions should be established by displaying operation data, alarming and other required information from the DCSs and linkage controllers on the CRT through programmable controllers and network of the coal and limestone transfer control rooms and ash disposal control rooms which are the common facilities.

⑩ For man/machine interface with plant operators, 3 CRT displays, 2 printers and 2 monitor TV sets (for drum water level and furnace fire viewing), etc. per power unit should be mounted on the control desk panel as peripheral equipment.

(b) Closed loop control (Refer to Figure 6-15-4-5.)

① To achieve rapid and high-fidelity response to the output instructions of power plant, a plant control system (co-ordinated boiler/turbine control system) should be applied to execute parallel control of boiler and turbine. This system controls the boiler and turbine in parallel according to the load requests from the load dispatching centre (DPC: Dispatch Power Control).

Information exchange between the load dispatching centre (LDC) and thermal power plant (TPP) is not only based on conventional telephone circuit but analog and digital signals will be transmitted by means of carrier waves to improve the follow-up between the load dispatching instructions and power generating systems.

② The co-ordinated boiler/turbine control should be capable of changing over the boiler and turbine follow-up modes as required. In addition, it should also be capable of performing operations based on load demands in the power plant independently from the DPC (ALR: Automatic Load Regulation).

The generator output should able to be limited depending on the thermal supply operating and stop conditions by varying the Load Hi-Limiter of the unit master control system to the specified values.

③ The target load control range of the unit master control system should be set as follows so that it can contribute significantly to the power transmission system under the DPC control:

Load control range of DPC	:	40 - 100% MW
Load change rate of DPC	:	2 - 3% MW/min.

However, the DPC signal should be held during changeover operations for starting or shutting down the auxiliaries such as the BFP and mills following change in the load.

④ As for the turbine control, the turbine speed, turbine valves and turbine start-up should be controlled with the digital EHC system of a low-pressure control oil system. Moreover, it should also be made possible to easily interface with the DCS. The overspeed limiting, vacuum limiting and other turbine protection interlock sequence safety devices should be included in the turbine control system.

⑤ Boiler control

The fuel control systems (fuel oil and coal systems), feedwater control system, air control system, super heat and reheat steam temperature and other control systems should be distributed and controlled.

(c) Sequence control

① The boiler purge interlock, boiler and turbine auxiliary start-up and shutdown, and burner start-up and shutdown should be separated from the DCS system and manually controlled by the operators from the respective logic sequencers and relay circuits. In this case, their states should be displayed on the operator console screens so that the operation conditions of equipment can be recognised visually and by alarming.

② The kick signal starting the operation of sequence control should be made manually by operator from the bench control board in the central control room. Similarly, it should be made possible to perform the burner extraction/retraction and ignition/extinction operation locally or from the [REMOTE/MANUAL] operation station on the bench control board.

(d) Protection circuit

① Should any trouble occur in equipment or control system, the plant conditions should be kept within the operation control values.

The main objective of its functions is to ensure safe start-up, operation and shutdown of the boiler equipment including crushers. coal feeders, burners and fan dampers and turbine generator pumps, as well as the feedwater heater drain, generator sealed oil, hydrogen gas equipment and other related equipment.

② In regard to the system configuration, the protective circuits including the logic should be made independent as far as possible so that any defect in one circuit would not affect another circuit. The system redundancy should be applied to important items including the backup logic, etc. The normal protection logic circuits, for example a boiler tripping circuit to deal with total burner loss and drum water level drop should naturally be provided. The turbine generator protective devices should be comprised of automatic monitoring and tripping systems.

(e) Operation display/alarm and performance calculations

① Among the alarm and trip indication data, a small amount of data which are specially important for the plant operation are selected to facilitate visual identification and simplify the display windows, and these data are displayed on the BTG panel.

The operation data required for safe and efficient operation of plant are displayed on the operator console and printed out by the printer. Such information is collected by a data acquisition system (DAS) which is one of the functions of DCS.

The conceivable display methods include a variety of forms, for example, by means of a colour bar chart or a mimic flow diagram covering process data and operating conditions of equipment. The actual selection will be made at the time of the detail design.

② The DAS (Data Acquisition System) performs about 40 items/unit of plant performance calculations (refer to Table 6-15-2-1). It can print out the operation record every hour and store all of the above data for the past one year in the auxiliary storage.

(f) Network

① For the purpose of sharing the use of plant information, providing real time data and retrieving historical data in graphical forms by making use of data highway, CRT monitors are installed on the desks of the management staff of the thermal power plant as a part of the DCS system as shown in Figure 6-15-2.

② Meanwhile, the water treatment equipment, coal/limestone receiving and transfer facilities and ash disposal equipment operated and controlled from the local control rooms can possibly be linked to and placed under integrated supervision of the DCS network in the central control room. For this purpose, it will be possible to connect the input/output (I/O) units through digital communications using optical cables.

(g) Interface between the LDC (Load Dispatching Centre) and TPP (Thermal Power Plant)

① Signals from LDC (Refer to Figure 6-15-2-5.)
The DPC signals from the LDC are modulated in a convenient form for communication before being transmitted to the TPP. The received signals are demodulated by the demodulator in each line terminal and transferred to the DCS.

② Signal regulator

The demodulated DPC signals are decomposed for each unit by the signal regulator, and each signal is connected to the APC (Automatic Power Control) as a demanded load signal in the form of unit DPC signal.

③ Operation mode switch

The following operation modes should be switchable between each other.

a. DPC

b. ALR

④ ALR (Automatic Load Regulator)

The target load of the ALR is set with the manual setting device at the input of the APC. The output change rate of the target load of the DPC or ALR should be switchable to 3 or more steps automatically according to the load. The ALR should be programmed so that it does not use the AFC signals which are input independently.

⑤ Correction of output instruction signals

The following corrections (limitations) should be applied to the instructions output from the LDC.

a. Limitations of output change rate of DPC or ALR signal

- Manual setting, plus automatic switching of change rate according to the output zone

b. Compensation for frequency variation (governor-free correction)

- The dead zone should be able to be set.

- The correction gain should be identical to the turbine inclination variation.

- An identical change rate limitation to that of the automatic follow-up regulator (AFR) of the load limiter should be provided for the upward output instruction which is issued when the frequency drops.

⑥ Change in the DPC instruction should be indicated by a buzzer beep and lamp lighting.

The buzzer should stop and light go out when the arrival confirmation push-button is pressed.

⑦ Measures in case of abnormality

a. Should the frequency transducer fall faulty, the frequency change compensation circuit and the power plant frequency control (FFC) signal should be blocked and an alarm be issued.

b. Should the generator output transducer fall faulty, all of the circuits which use its output signal should be blocked, and the necessary interlocking to prevent the system from being operated based on erroneous signals should also be provided. Also, an alarm should be issued and the faulty contact signal should be transmitted to the LDC.

c. Should the DPC incoming signal deviates out of the signal range between the previously-specified maximum and minimum signal levels, the following actions should be taken.

- DPC signal abnormality alarm should be issued.
  Alarm should be displayed on the control boards
  The signal should be returned to the LDC as the DPC abnormality signal.

- Attempts should be made to continue the current output and stable operation.
  The operation mode should be changed.

  DPC → ALR

⑧ Signals from LDC to TPP

a. DPC signal 0 - 5 V* (4 - 20 mA), 0 - 300 MW

b. Contact LDC abnormal,
DTM abnormal,
System isolated, etc.

- (Reception in a digital form is also accepted if the APC uses a digital system.)

⑨ Signals from TPP to LDC

a. Generator output 0 - 5 V* (4 - 20 mA), 0 - 300 MW

b. Contact DPC running, ALR running,
APC abnormal,
Generator output transducer abnormal

(h) System diagram

The standard interface between the DPC and APC (Automatic Power Control) is shown in Figure 6-15-6.

Table Basic Specifications of DPC (Dispatch Power Control) System

Major function			Basic program for analog and digital logic operations and advanced operations
Number of addressable blocks			2,000 - 10,000
Typical period (msec.)			100 - 500
Directly coupled module process I/O	Analog inputs	Rating	1-5 VDC, 4-20 mA
		Quantity	4-8
	Analog outputs	Rating	1-5 VDC, 4 - 20 mA
		Quantity	2-4
	Digital inputs	Rating	24 V/125 VDC
		Quantity	3-4
	Digital outputs	Rating	Isolated open collector
		Quantity	2-4
Other I/O units			Module bus, Expander bus, Printer/terminal, RS-422 (DCS and DIS)
MPU	Bits	16 or 32	
	Clock rate	8 MHz	
Memory capacity, type (in bytes)		ROM	32K-265K
		RAM	24K-516K
		NVM	20K-80K

(Note) NVM: Non-vapoured memory
ROM: Read-only memory
RAM: Random access memory
MPU: Microprocessor unit

(4) Sensor and transmitter

(a) Requirements for transmitters

① Excellent precision: 0.5% or less

② Sufficiently large range ability: 1:10 or over

③ Less drift error due to environmental change
Ambient temperature change (Δt)/50°C: 0.2% or less (to span)
Static pressure change: 0.2% or less (to span)

④ Compatibility with replacement having specifications complying with the ISO Standards

Power source:	18 - 42 VDC
Load resistance:	250 - 600 Ω
Output signal:	4 - 20 mA DC, two-wire system

(b) Thermo elements

① The specifications should be in compliance with the ISO Standards. In principle, double elements should be used.

RTD:	Pt. 100 ohm at 0°C, three-wire system
Thermocouples:	Type K (C, A)
	Type E (CR, C)
	Type J (I, C)
	Type T (C, C)
Tolerance:	Class 0.75 or above

(c) Redundancy design of sensors and transmitters

The sensors and transmitters used for important plant control and interlock should use smart transmitters and be duplicated or consist of "2-out-of-3-circuits" as required to realise an instrumentation system excellent in reliability and stability. The above should be applied to, but not limited to, the following systems:

- Master pressure
- Main feedwater flow
- MIW transducer
- Drum level
- Turbine oil temperature
- Main steam temperature
- Turbine speed
- Furnace pressure and temperature
- Unit interlock circuits (for trip and run-back) etc.

(5) Uninterrupted power source (UPS) unit for distributed control system (DCS)

While adopting a highly reliable and stable DCS system with high-level multifunctionality as the plant instrumentation system, a dedicated uninterrupted power source (UPS) for the DCS system should be installed taking into account the importance of this system and the effects of possible power supply failure thereto.

(a) Outline of the UPS

Consisting of rectifiers, an inverter, a thyristor switch and other components, the UPS is designed to supply stably an uninterrupted AC power to the load at constant voltage and frequency in combination with a battery which is provided separately from the UPS.

Note: This unit is normally synchronised with the commercial mains frequency, and the frequency becomes constant only when it is isolated and crystal-synchronised.

(b) Basic circuits

The basic circuit system is as shown in Figure 6-15-7.

① Types of power sources to the UPS and operation of the UPS

a. The power input terminals on the CVCF block include two terminals for the "normal AC power source" and "backup DC power source."

b. The power sources to the respective input terminals are as described below:

1) Normal AC power source (unit power): Unit MC system (440 V AC)
2) Backup DC power source: Station service battery system (110 V DC)
3) Backup AC power source: Emergency diesel system or common power source system (440 V AC)

Note ① In principle, the feeders to the normal and backup AC power sources should be separate.

Note ② The number of phases of the AC sources should be single in case of small capacity and three in case of large capacity.

c. Application of power source

The "normal AC power source" should be used normally. The "backup DC power source" should be used as the back-up of the normal AC power source.

② Bypass circuit for maintenance

a. A bypass circuit should be provided to make it possible to supply power source to the load side even during inspection of the CVCF block.

b. In principle, the MCCB for changing over to and from the inverter and maintenance bypass circuits should have a mechanical interlock system.

③ Warning, display and protection functions

a. A UPS fault alarming display should be provided in the central control room.

b. A function for protecting against overcurrent on the load side should be provided.

(c) Basic specifications

① Input current

a. Normal and backup AC power sources

	Items	Specifications
AC input	No. of phase	Single- or 3-phase
	Rated voltage	440 V
	Voltage regulation	-15 to +10%
	Rated frequency	50 Hz
	Frequency range	50 Hz ±5%

b. Backup DC power source

	Items	Specifications
DC input	Rated voltage	110 V or 125 V
	Voltage regulation	-20 to +30%

(However, 150 V should not be exceeded).

c. Output power source

	Items	Specifications
AC output	Rated voltage	105 V or 210 V AC
	No. of phase	Single- or 3-phase
	Voltage regulation	Within ±2%
	Rated frequency	50 Hz
	Frequency regulation	Within ±0.5 Hz
	Wave form distortion rate	5% or less (at lagging power factor of 0.9)
	Rated load factor	0.9 - 0.7
	Voltage adjustable range	±5.0% (at rated input)
Transient characteristics		
	Regulation at rapid load change	Within ±10%
	Regulation at rapid AC input change	Within ±10%
	At power outage/restoration time	Within 10%
	Voltage setting time	Within 8 cycles

(6) Local control system and anti-freezing countermeasures

(a) The boiler and turbine local control shall use a pneumatic local minor control system. The sensors, transmitters and controllers should be concentrated on a stationer or local cubicle to ensure easy maintenance and save the installation cost.

(b) As the countermeasure against freezing of fuel piping lines and instrument detector pipes, a hot water trace system should be attached to each of them.

(c) The outdoor instrument detector pipes and fuel pipes should use hot water trace pipes wrapped with thermo-cement insulation, and a drawing stop valve should be provided for each trace pipe (10 to 12 mm dia.). The designed hot water temperature should be 65°C and the warmed fluid should be kept at no less than 45°C even in the winter.

Table 6-15-2-1 PLANT PERFORMANCE CALCULATION (Example)

B-01 HEAT INPUT TO BOILER FROM FUEL
B-02 HEAT OUTPUT FROM BOILER
B-03 ENTHALPIES AT TERMINAL POINTS
B-04 EXPECTED BOILER EFFICIENCY
B-05 DRY FLUE FLOW FOR FUEL
B-06 THEORETICAL DRY FLUE FLOW FOR FUEL
B-07 EXCESS AIR RATIO
B-08 ABSOLUTE HUMIDITY
B-09 CORRECTED BOILER EFFICIENCY
B-10 CORRECTION BY DRY GAS LOSS
B-11 CORRECTION BY ATOMSPHERIC HUMIDITY
B-12 CORRECTION BY WATER & HYDROGEN CONTENT
B-13 CORRECTION BY ATOMIZING STEAM LOSS
B-14 TEMPERATURE EFFICIENCY OF AIR HEATER

T-01 TURBINE GENERATOR HEAT RATE
T-02 BOGIE GROSS TURBINE GENERATOR HEAT RATE
T-03 CORRECTED TURBINE GENERATOR EFFICIENCY
T-04 BOGIE EFFICINCY OF TURBINE GENERATOR
T-05 HP TURBINE EFFICIENCY
T-06 IP TURBINE EFFICIENCY
T-07 LP TURBINE EFFICIENCY

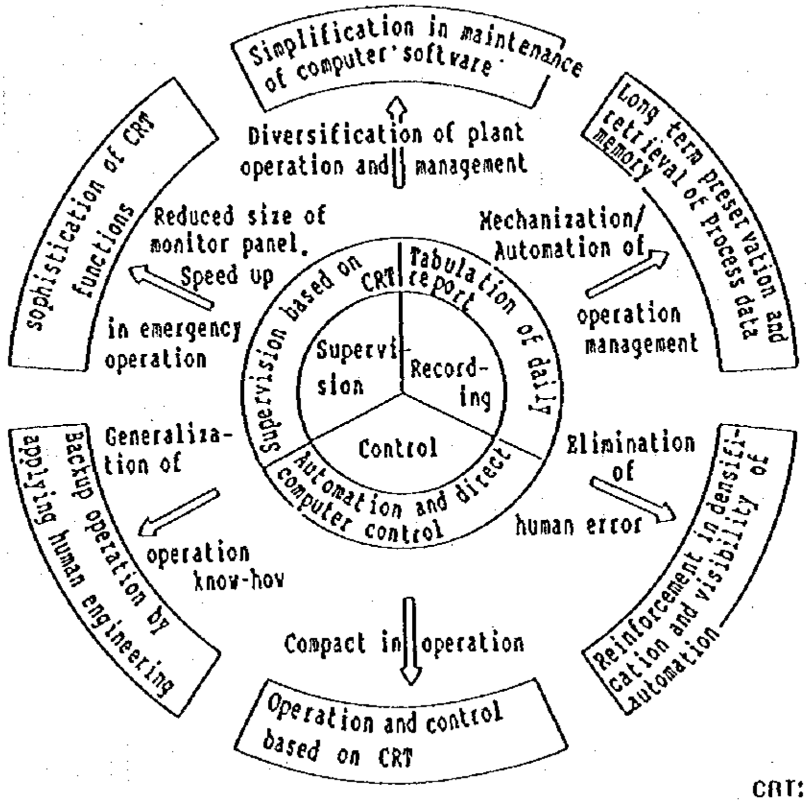
K-01 CIRCULATING WATER TEMP. AT CONDENSER INLET
K-02 CLEANLINESS FACTOR OF CONDENSER
K-03 ACTUAL HEAT TRANFER COEFFICIENT OF CONDENSER
K-04 DESIGN HEAT TRANFER COEFFICIENT OF CONDENSER
K-05 EXCHANGING HEAT IN CONDENSER
K-06 DEFLECTION OF CONENSER VACUUM
K-07 EXPECTED CONDENSER VACUUM

H-01 NO. 6 HP HEATER PERFORMANCE
H-02 NO. 5 LP HEATER PERFORMANCE
H-03 NO. 3 LP HEATER PERFORMANCE
H-04 NO. 2 LP HEATER PERFORMANCE
H-05 NO. 1 LP HEATER PERFORMANCE

E-01 GENERATOR POWER FACTOR
E-02 HOUSE CONSUMPTION RATIO
E-02 GROSS PLANT EFFICIENCY
E-03 NET PLANT EFFICIENCY
E-04 NET PLANT HEAT RATE

Table 6-15-2-2 ALR-DPC SPECIFICATION

CLASSIFICATION	ARTICIES	MOUNTED ON	RANGE etc.
Push Button Switch	ALR-DPC Mode Selection	SVP	ALR-DPC
	Load Change Rate Mode Selection	SVP	AUTO-MAN
Setter	ALR Demand Set (INC, DEC)	SVP	0-300MW
	Max Load Set (INC, DEC)	SVP	0-300MW
	Min Load Set (INC, DEC)	SVP	0-300MW
	Load Change Rate Set (INC, DEC)	SVP	0-15MW/Min
Indicator	Load Setter	CRT	0-300MW
	MW Demand		0-300MW
	Generator Output		0-300MW
	Max Load Set Value		0-300MW
	Min Load Set Value		0-300MW
	Load Change Rate (Auto)		0-15MW/Min
	Load Change Rate (Man)		0-15MW/Min
	Generator Frequency		45-55Hz



CRT: Cathode Ray Tube

Figure 6-15-2-1 SOPHISTICATION OF THE ROLES AND EXPANSION IN APPLLCATION OF COMPUTER FOR THERMAL POWER PLANT

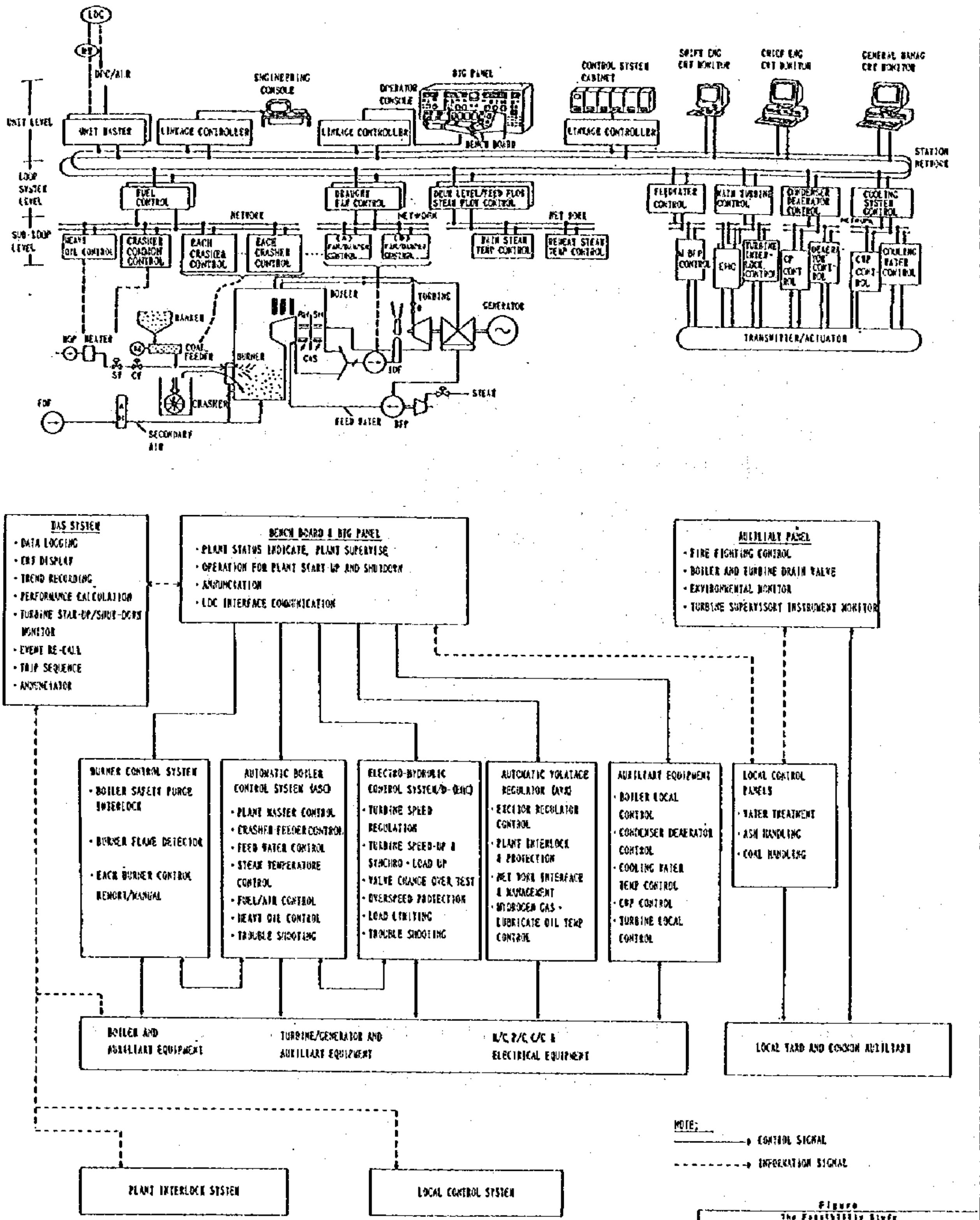


Figure 6-15-2-2 DCS SYSTEM CONFIGURATION (A)

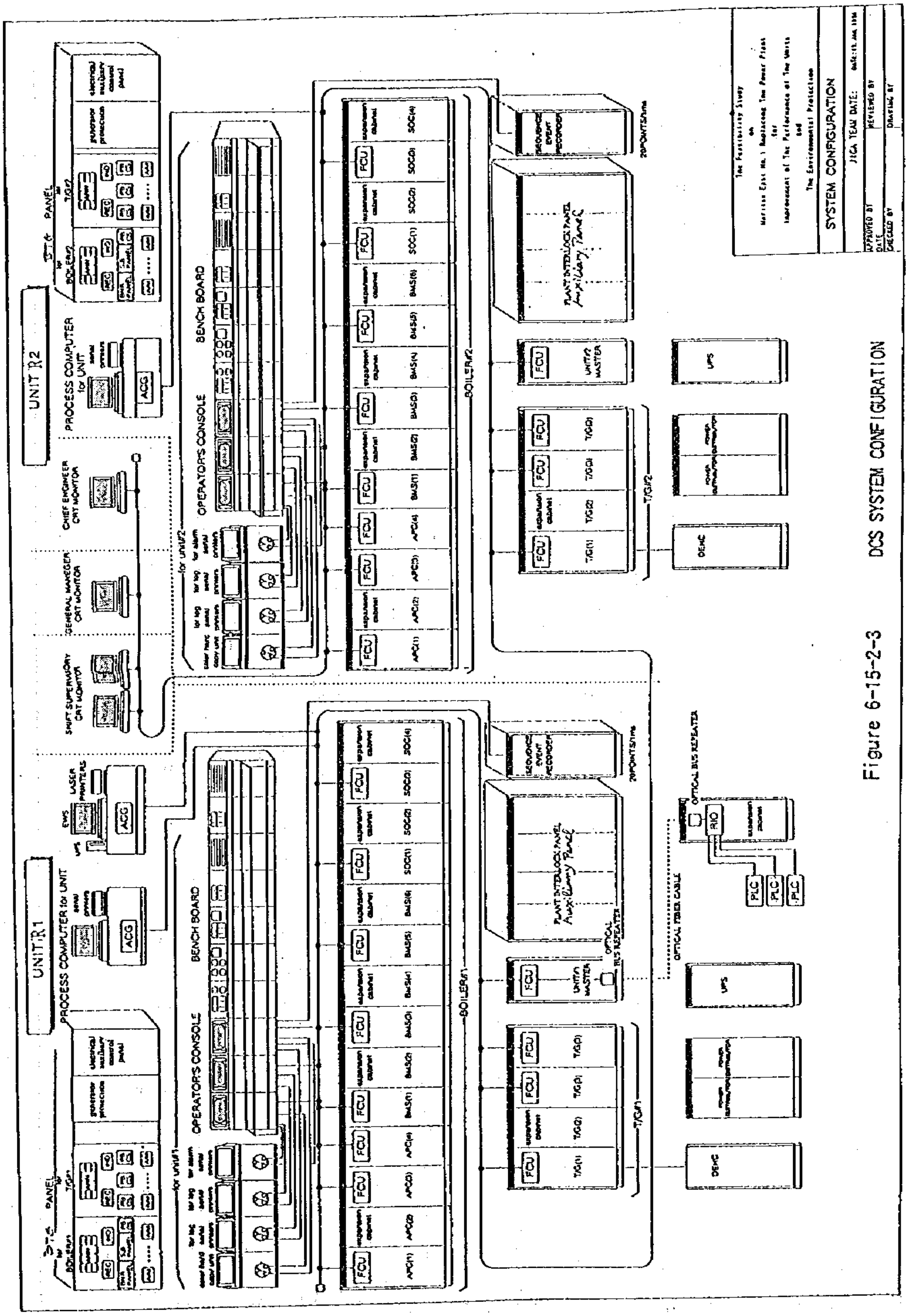


Figure 6-15-2-3　　DCS SYSTEM CONFIGURATION

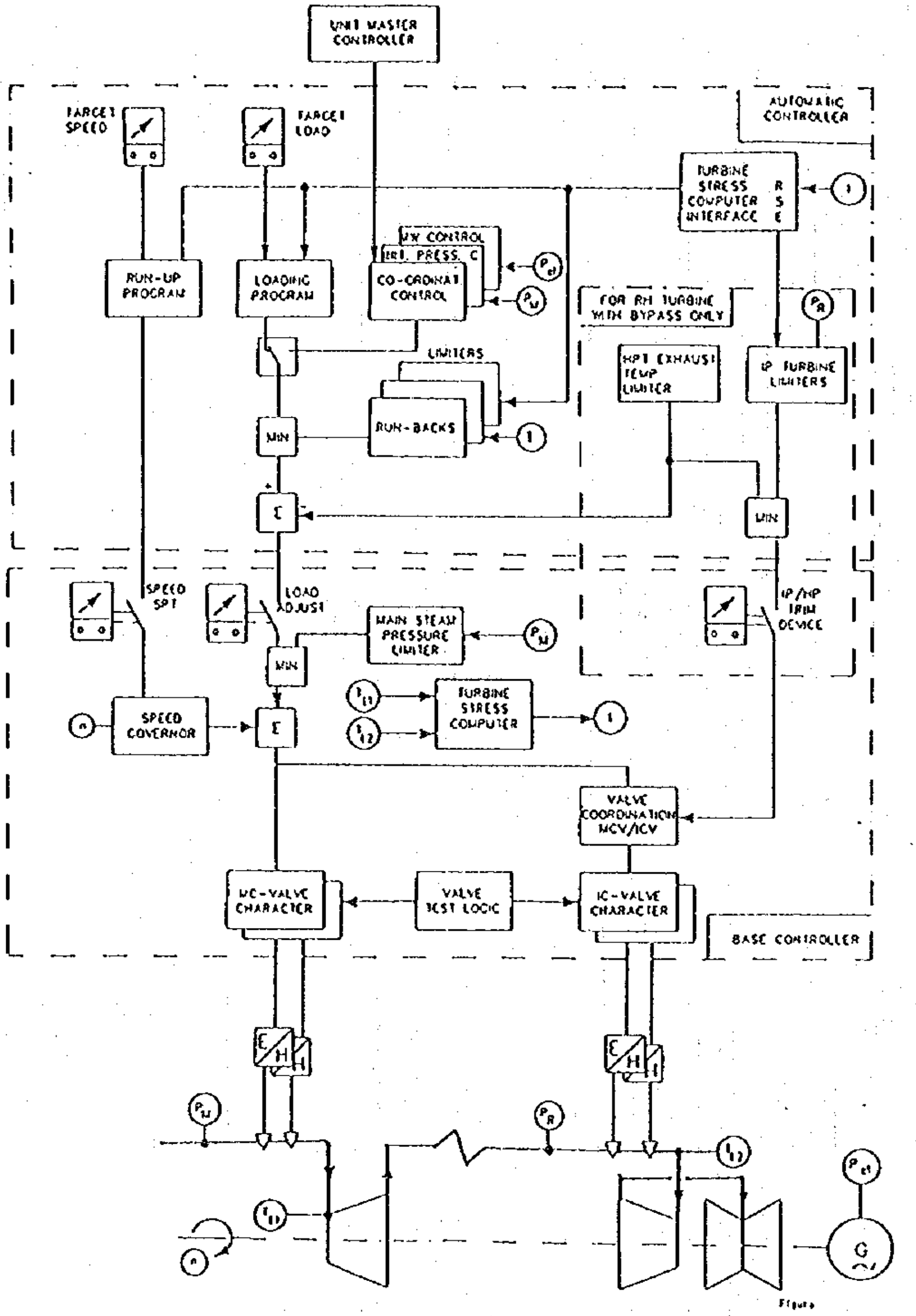


Figure 6-15-2-4　DEHC FUNCTIONAL STRUCTURE

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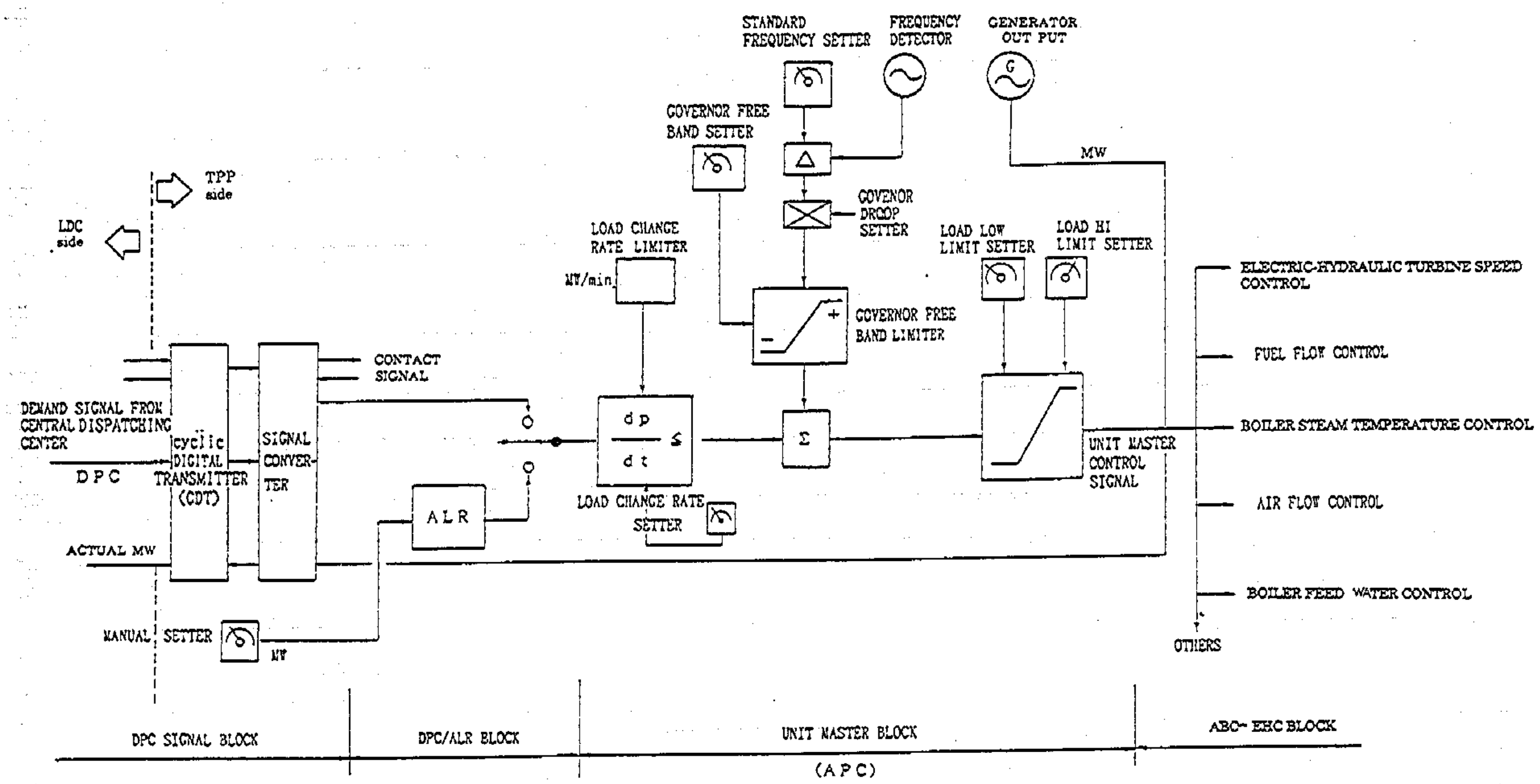

Figure 6-15-2-5 DPC-UNITMASTER CONTROL BLOK

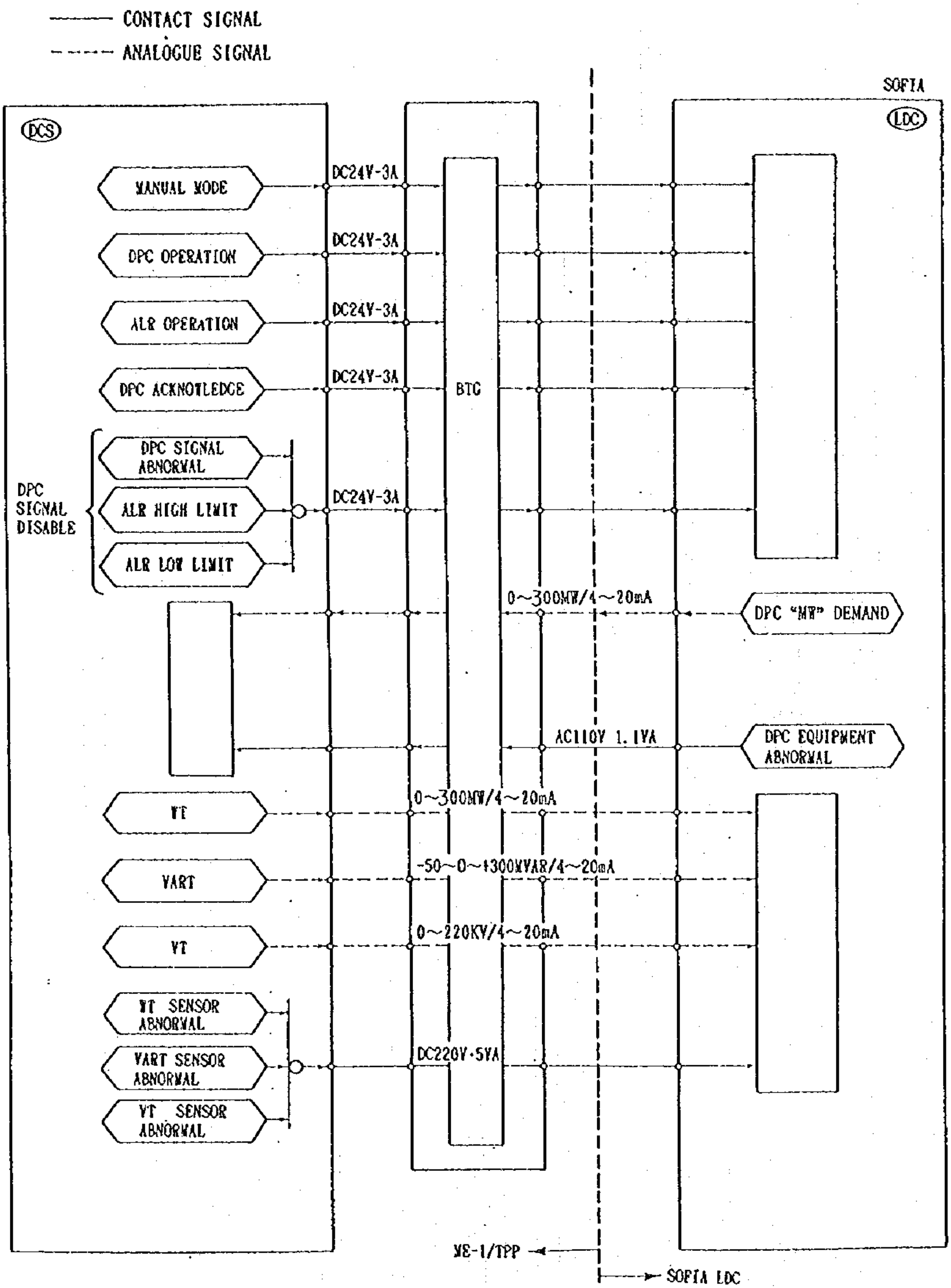

Figure 6-15-2-6 DPC INTERFACE SOFIA AND ME-1/TPP

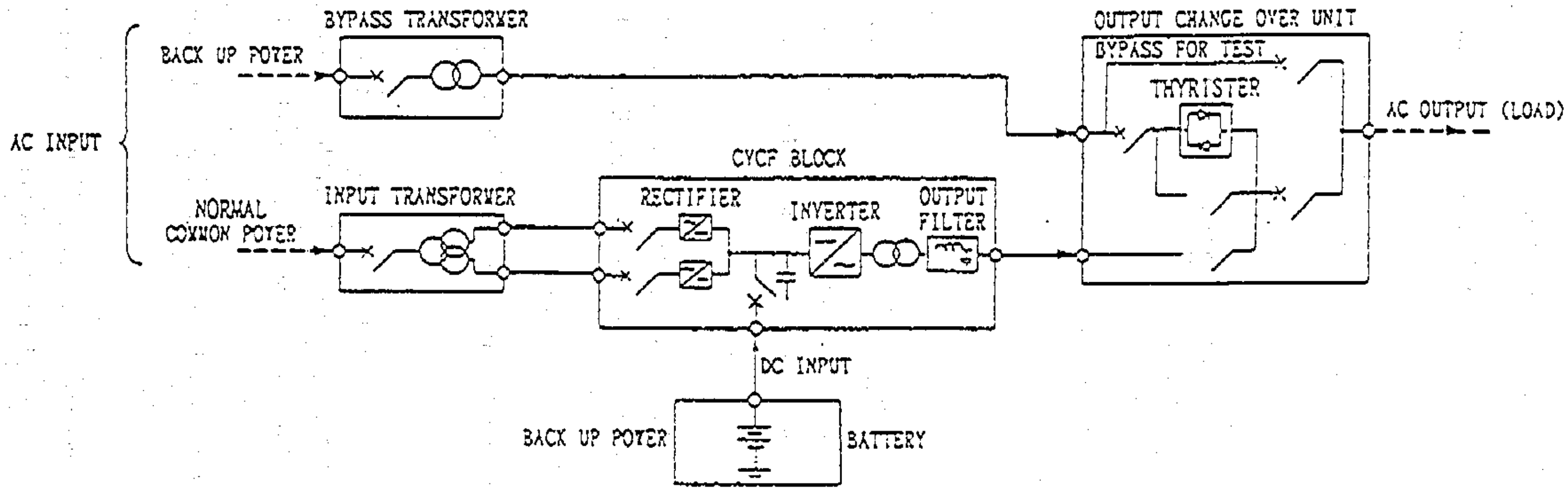

Figure 6-15-2-7 UPS BASIC CIRCUIT

6.16 Switchyard and Substation

(1) Maritsa East No. 1 Thermal Power Plant, Switchyard

New equipment for the outdoor switchyard will be installed at the former outdoor equipment site of the Nos. 5 and 6 units.

The single line diagram plan is shown in Figure 6-16-1. The layout plan is shown in Figures 6-16-2 and 6-16-3.

(a) Regarding the circuit, considering the importance of this plan on the power system, a double bus circuit with high supply reliability will be used.

(b) The main transformer and starter transformer will be connected with a circuit breaker by connecting overhead lines.

(c) The bus will be of aluminum wire.

(d) As a result of discussion with NEK, gas circuit breaker will be used. There will be 3 breaker sets for the generator side, 2 sets for the line side and 1 set for the bus tie.
The ratings will be based on IEC standards. The rated voltage will be 245 kV, the rated current 1,250 A and the rated interrupting current 20 kA.

(e) Disconnecting switch will have earthing switch according to Bulgarian standard. The required amount is 6 sets for the generator side, 6 sets for the line side and 2 sets for the bus tie.

The ratings will be based on IEC standards. The rated voltage will be 245 kV and the rated current 1,250 A.

(f) In the case of the instrument transformers, 12 current transformers and 4 potential transformers will be used for measuring and to protect lines, buses and transformers. The specifications will be decided after the protection and control methods are studied.

(g) To protect the switchyard equipment, arresters will be installed in two places, at the line and the transformer.

(h) A pilot wire protection method will be used to protect the transmission line, with pilot wire newly installed between the power plant and substation.

(2) Maritsa East No. 1 Substation (Galabovo)

The existing outdoor equipment will be removed and outdoor equipment for R1 and R2 units will be newly installed at the site. Equipment between the line inlet and the 220 kV bus outlet will be removed.

The single line diagram plan is shown in Figure 6-16-4. Figure 6-16-5 shows the layout plan.

Principal specifications will be the same as Maritsa East No. 1 Thermal Power Plant, Switchyard

The required amount is 3 sets of circuit breakers, 11 sets of disconnecting switches, 6 current transformers, 2 potential transformers and 2 arresters on the line side.

(3) Transmission Line Facilities

(a) Outlines of Facilities

Figure 6-16-6 shows the power system diagram covering ME-1 TPP and its vicinities. Transmission lines route is indicated as Figure 6-16-7.

Until the shut-down of former Unit-5 and 6 , transmission lines comprised four routes with 6-circuit. All transmission lines are connected to the Galabovo Substation, situated approximately 5 km away from the power plant.

Of the four routes, three routes (transmission lines for former Unit-1 - 5) run directly from the power plant over Rozovkladentz Lake to the substation. The remaining route (transmission line for former Unit-6) passes along the right-hand side of the lake, as viewed from the power plant , to the substation.

The voltage of the transmission lines connecting Unit- 1 to 4 respectively is 110 kV, and the voltage of the transmission lines connecting to former Unit-5 and 6 respectively is 220 kV.

After the shut-down of former Unit-5 and 6 , a change was made at the outlet of the power plant and at the inlet of the Galabovo Substation to provide the current connections of the transmission lines as shown below:

* Unit-1 transmission line → Unit-1 transmission line is used.
* Unit-2 transmission line → Unit-3 transmission line is used.
* Unit-3 transmission line → Former Unit-5 transmission line is used.
* Unit-4 transmission line → Former Unit-6 transmission line is used.
* Unit-2 and Unit-4 transmission lines → Operation temporarily halted.

(b) Operation of Transmission Lines after Improvement

Transmission lines for former Unit-5 and Unit-6 will be reused. However, being about 35 years old and not at all well maintained, the operating conditions of transmission line facilities are unsatisfactory.

Concretely, there are some dirty insulators and ground wires are partially cut. Particularly, the foundations of several towers of the transmission lines for former Unit- 6 are very bad condition.

For this reason, detail survey of the foundations of towers and repair work as exchange of insulators and replacing of lines should be need.

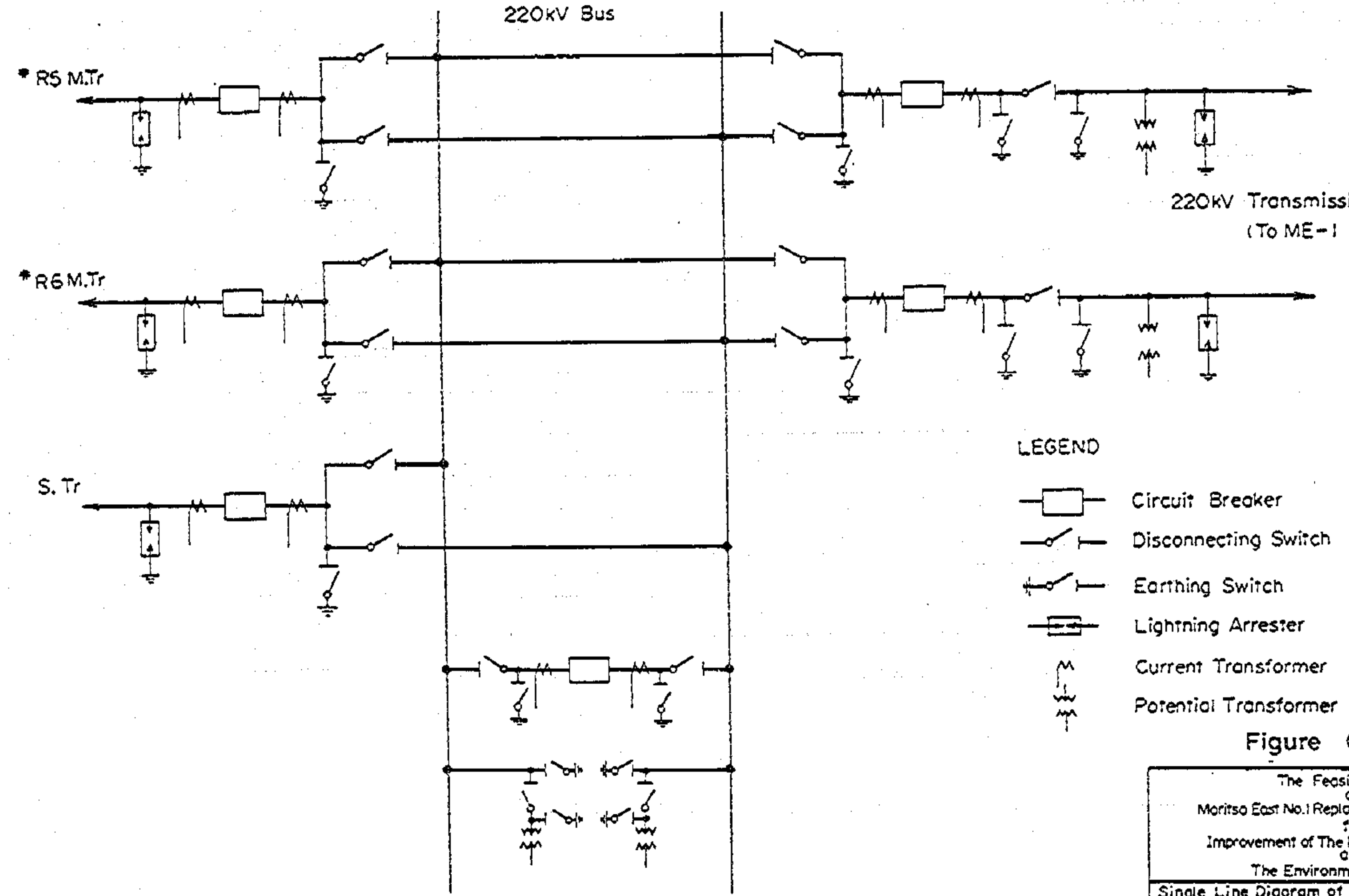

Figure 6-16-1

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

Single Line Diagram of Switchyard (ME-1 TPP Side)

SCALE:

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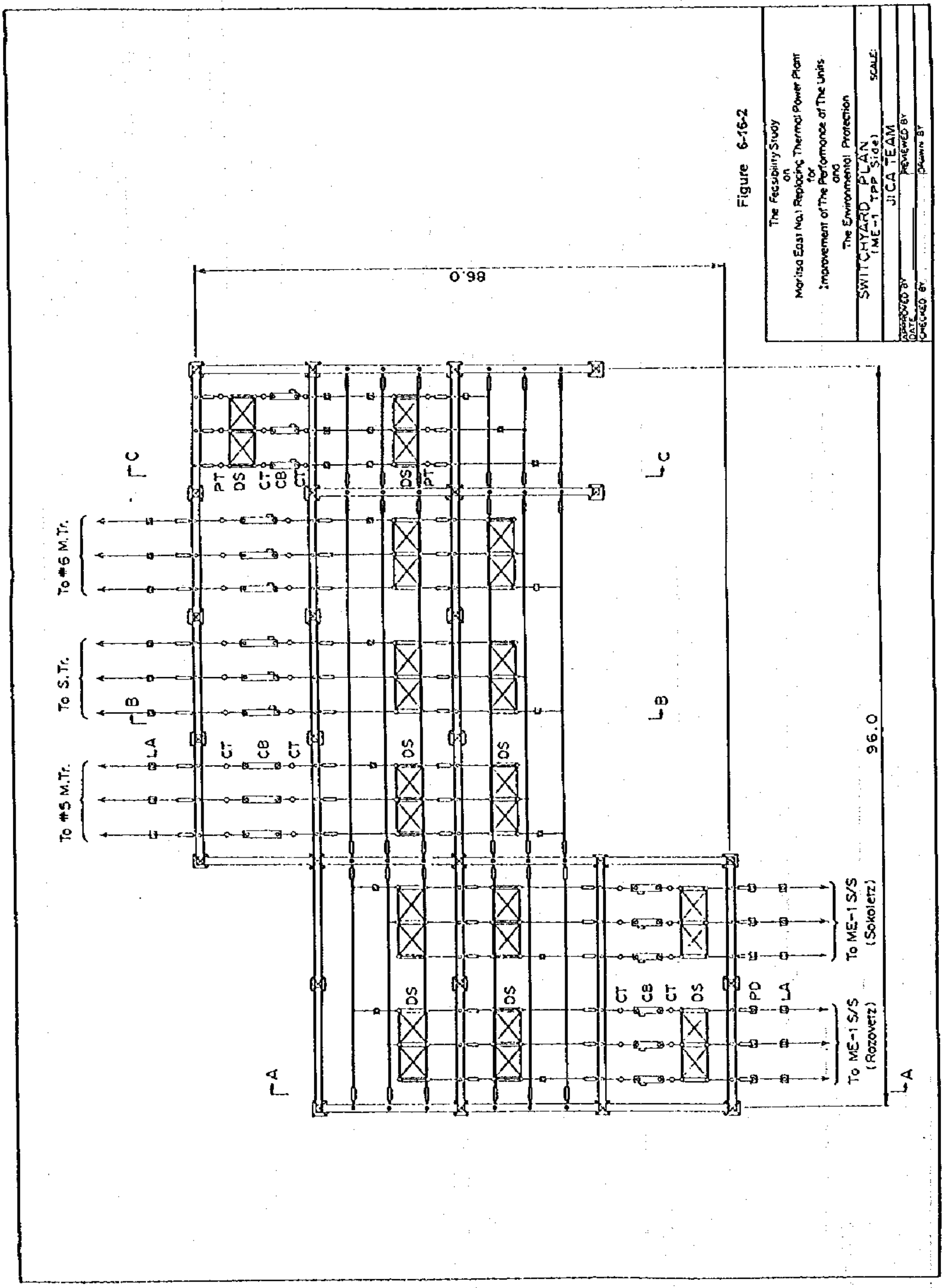
Figure 6-16-2
The Feasibility Study
on
Maritsa East No.1 Replacing Thermal Power Plant
for
Improvement of The Performance of The Units
and
The Environmental Protection
SWITCHYARD PLAN
(ME-1 TPP Side)
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86.0
96.0
To #5 M.Tr.
To S.Tr.
To #6 M.Tr.
To ME-1 S/S
(Rozovetz)
To ME-1 S/S
(Sokoletz)
LA
CT
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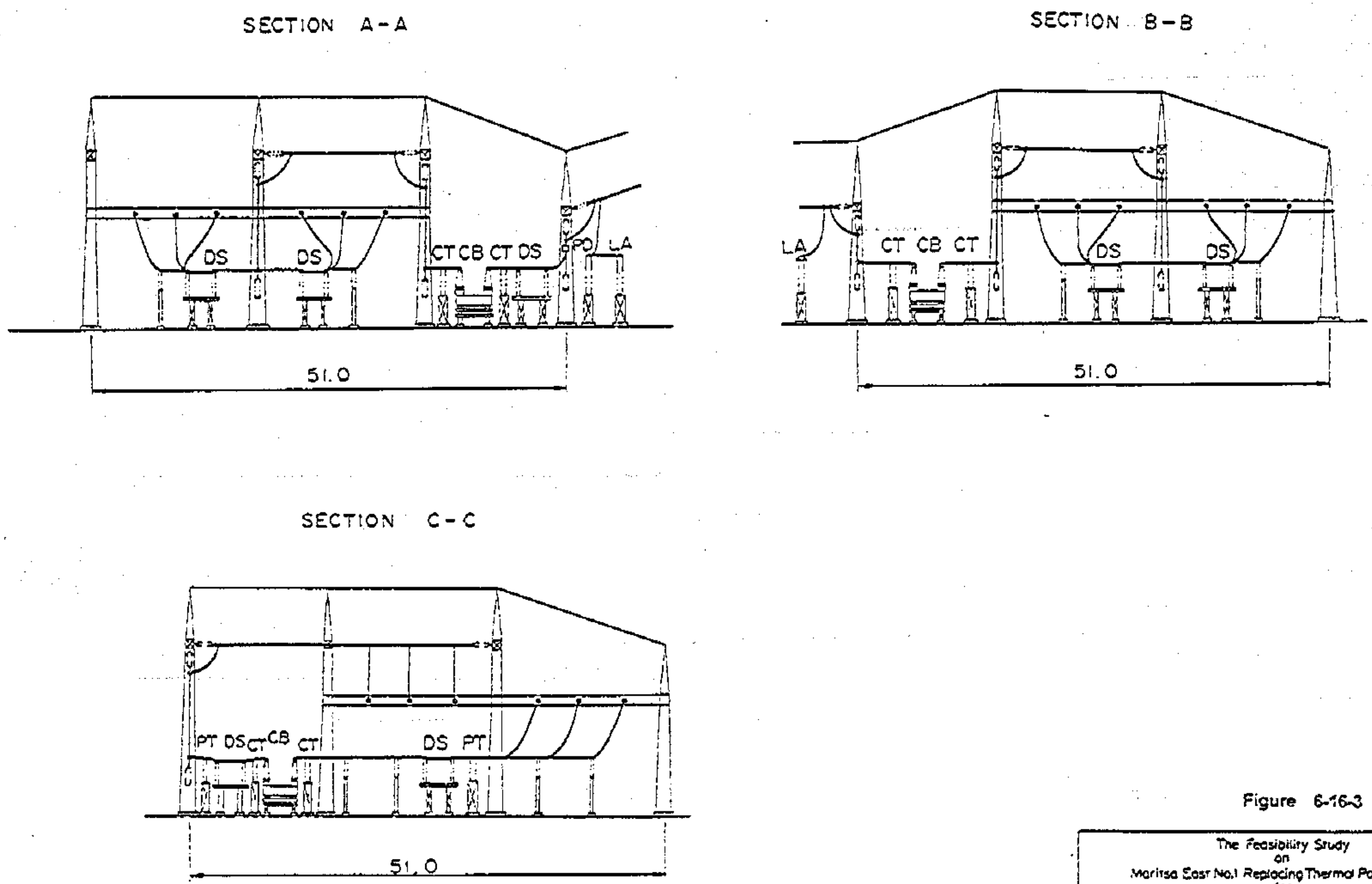

Figure 6-16-3

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

SWITCHYARD SECTION
(ME-1 TPP Side)
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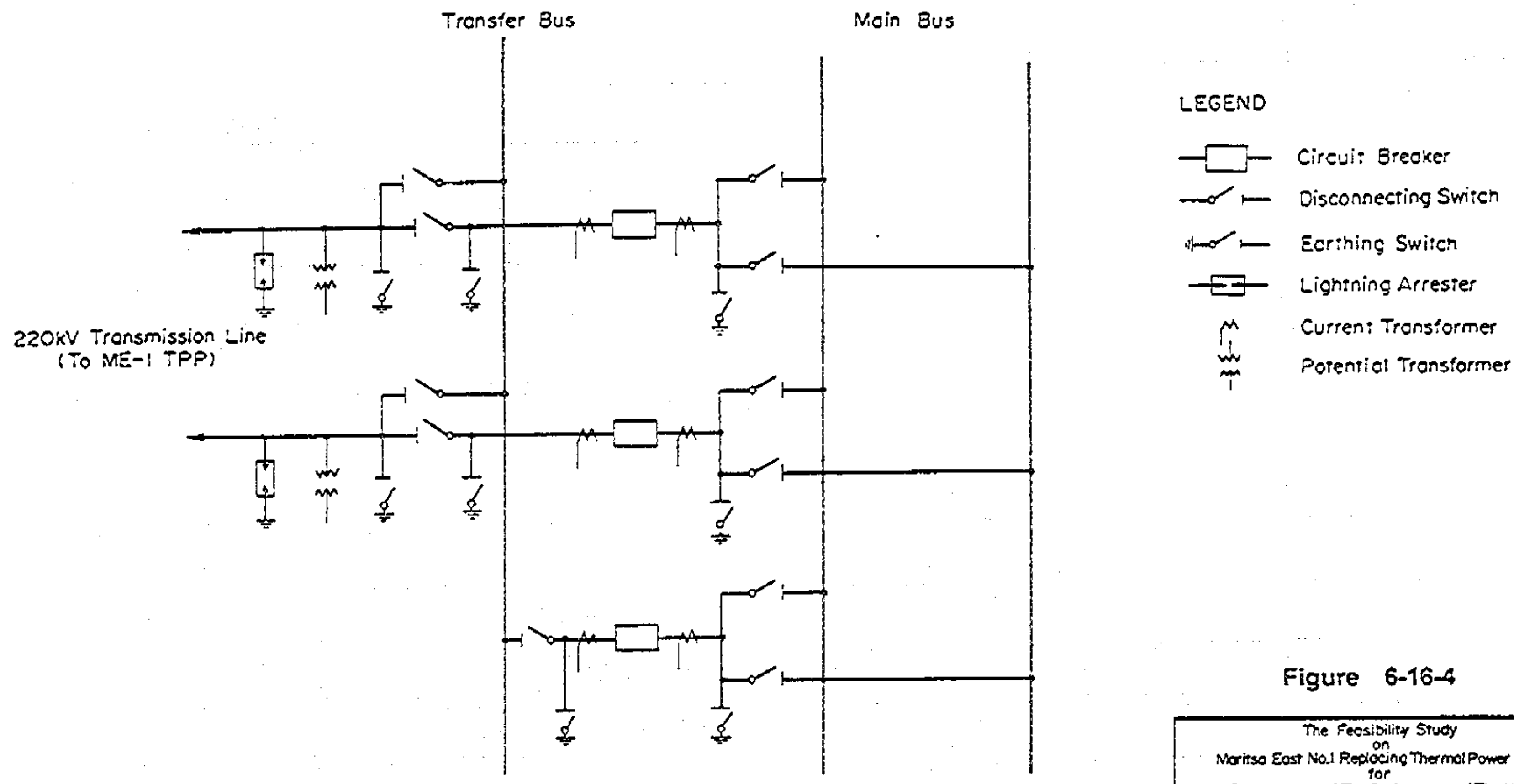

Figure 6-16-4

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

Single Line Diagram of Switchyard (ME-1 S/S Side)		SCALE:	
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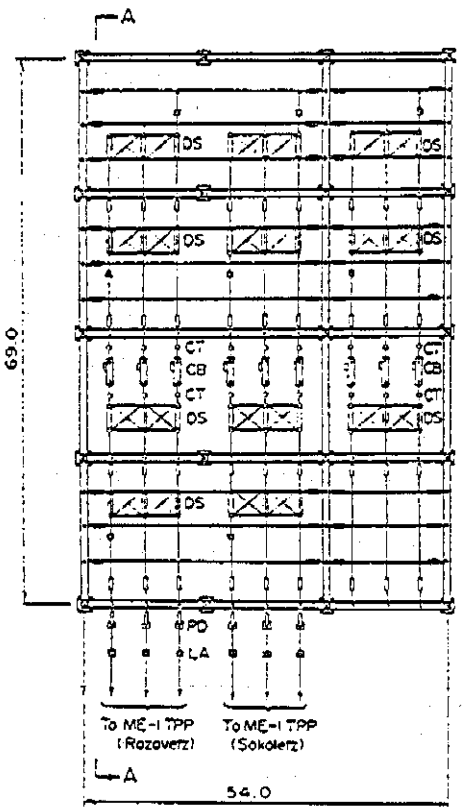

SECTION A - A

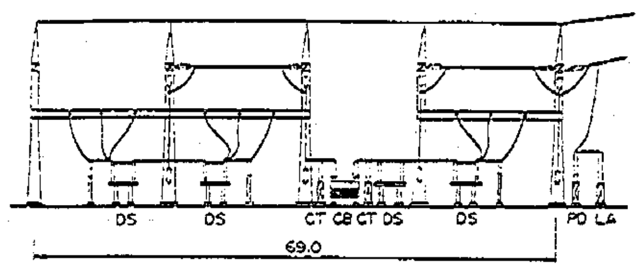

Figure 6-16-5

The Feasibility Study on Maritsa East No.1 Replacing Thermal Power Plant for Improvement of The Performance of the Units and The Environmental Protection
PLAN OF SWITCHYARD (ME-I S/S Side) SCALE:
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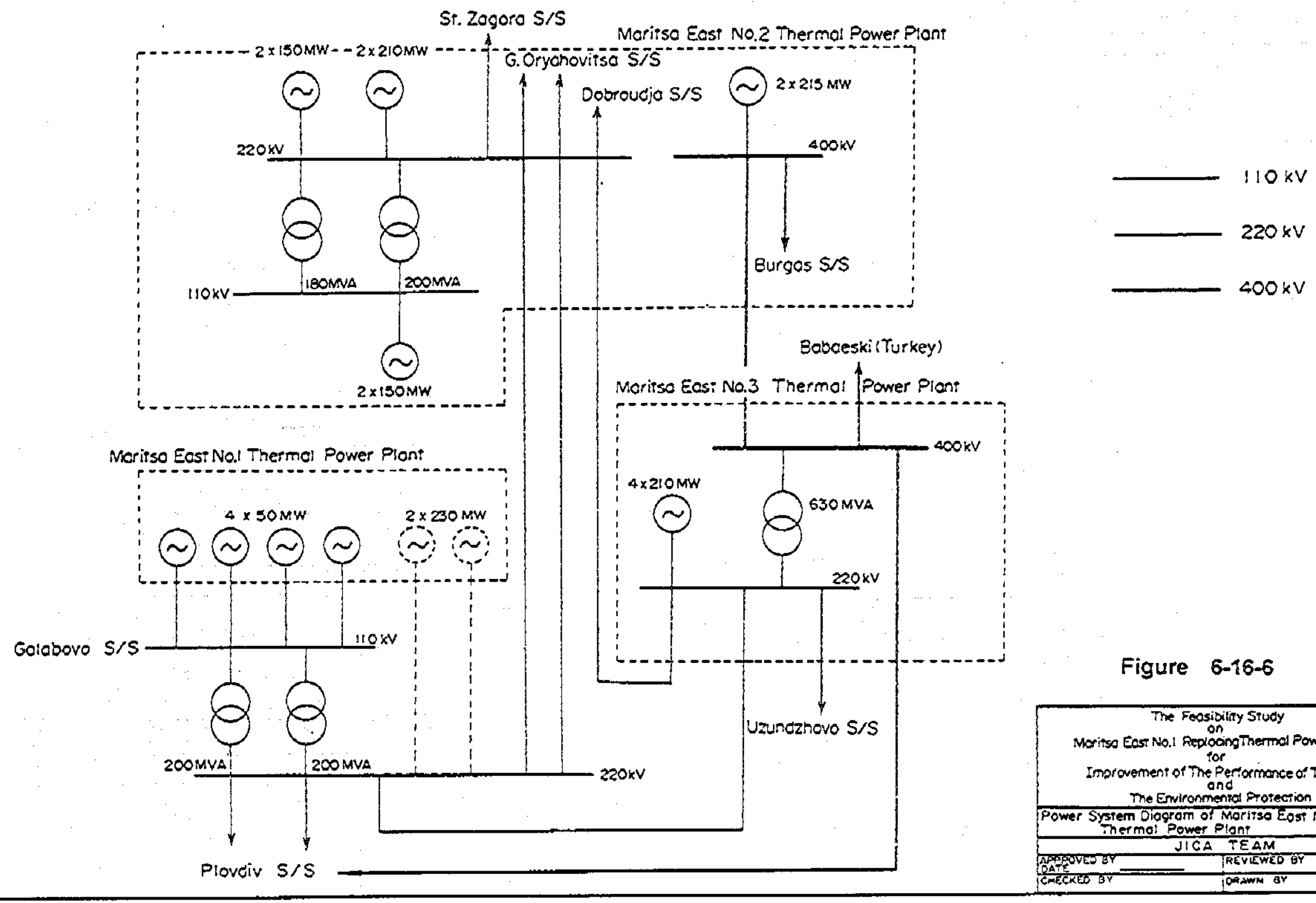

Figure 6-16-6

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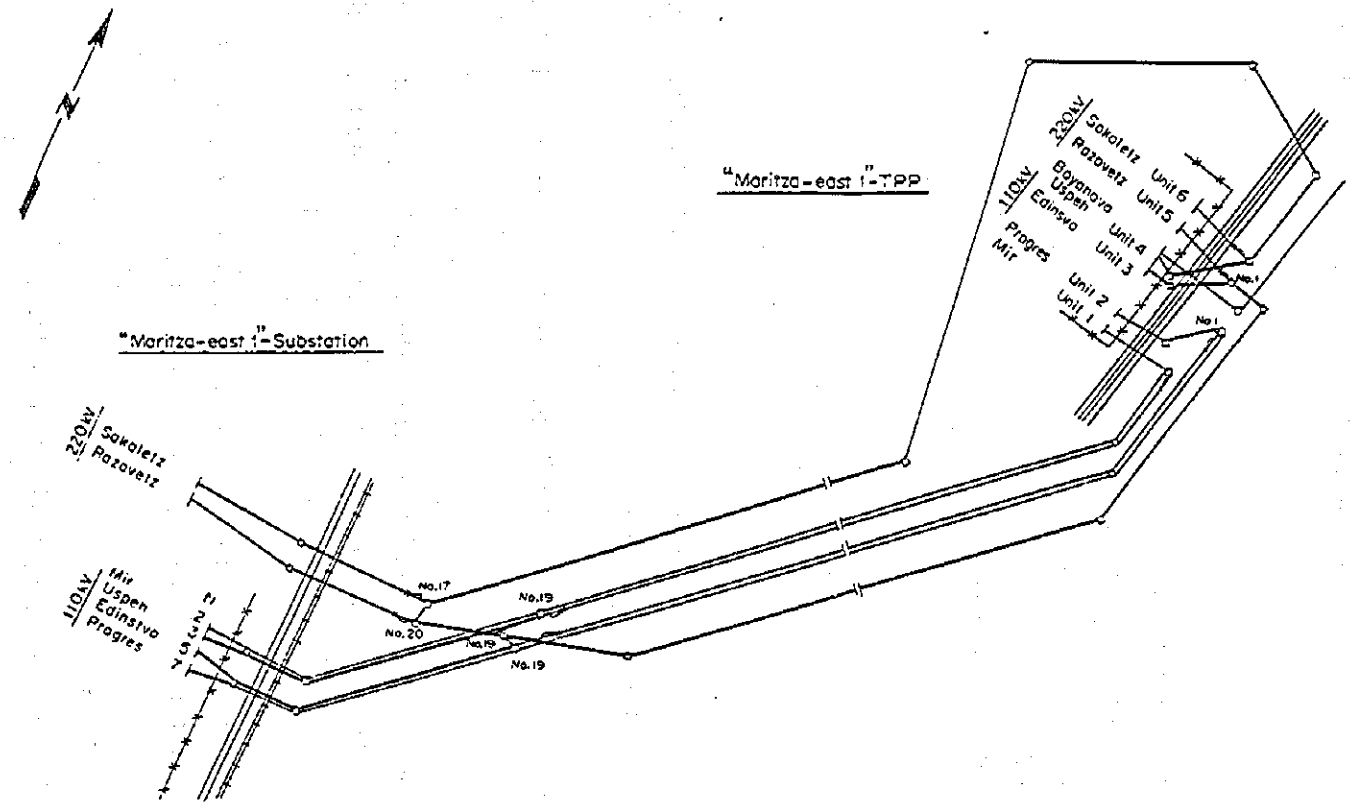

Figure 6-16-7

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

TRANSMISSION LINES ROUTE OF MF-1 TPP | SCALE:

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6.17 Buildings and Stack

6.17.1 Buildings

(1) Conditions to be studied

The following conditions were studied in order to study the volume, shape and structure of the buildings.

- Equipment arrangement plan
- Equipment transportation plan
- Access route for operation and maintenance
- Arrangement of the pipes and cables
- Load conditions
- Interfacing with the existing building
- Soil conditions
- Bulgarian design codes
- Construction schedule

(2) Results of study

- The scale and structure of all buildings are shown in Table 6-17-1. Details of each building are shown in Tables 6-17-2 through 6-17-12.

- The drawings for the turbine hall and boiler house are shown in Figures 6-17-1 through 6-17-4.

- The substructure of heavy load buildings is planned to be directly supported on the hard silt layer located 10m deep below the ground level, while the substructure of light load buildings on the upper sand layer of which the N value is about 15.

- Load: The design loads are as follows, and the combination of these loads should be studied, referring to the relevant domestic codes, for detail.

  - Weight (Dead load)
  - Effective load (Weight of people and equipment : Live load)
  - Wind load : 38 kg/m^2
  - Snow load : 40 kg/m^2
  - Assembling load
  - Crane load

- Pipe and cable load
- Seismic load

- Calculation method of seismic load: The seismic load is calculated by the following formula.

Q = A x I x S x W

Where; Q : Horizontal seismic load

A : Area coefficient (maximum value for this project: 0.27)

I : Importance coefficient (1.5 for thermal power station)

S : Response coefficient (Steel structure : 0.2 to 0.25,

Reinforced concrete : 0.2 to 0.3,

Stack : 0.35)

W : Weight of building

As a result of calculation by the above formula, the seismic load is within the below range.
Q = (0.081 to 0.142) x W

- Bulgarian standards for installation of lightning arrester and for the covered area is available. The lightning arrester covers the area of about a 45 degree angle.

(3) Others

- There is a "Fire Protection Code No. 2", which specifies the installation standards of fire extinguishing equipment and fire alarm system. This code should be complied with in this project.

- The area is within a zone nominated for industry.

- The space between buildings should be 4m or more. If not, a fire-proof structure should be provided.

- Nonflammable or non-likely-flammable material should be used for exterior walls of the turbine hall.

- It is not necessary for the steel structure to be provided with fire-proof protection.
- Fire-proof area dividing is not restricted.

- Noise and vibration control during construction is not restricted in this area.

- No specific application for confirmation of building construction is required, but a confirmation meeting with the fire protection authority is required during the design of the building.

- Members from the Ministries of Construction, Fire Protection, Environment and Labor will check the construction conditions two times or so during construction.

6.17.2 Stack

(1) Conditions to be studied

The following conditions were checked in order to determine the stack shape.

- Flue gas volume
- Flue gas temperature
- Height of stack
- Flue gas speed

(2) Results of study

- A flue is separately provided for each of units R1 and R2.

- Two inner flues are provided within the stack, and the outer shell of reinforced concrete bears outer force.

- The inner flue size was determined based upon the conditions of item (1), and then the outer shell size was determined.

- The structure of the outer shell was made of reinforced concrete because of economical advantage compared with steel. Also, the shape was cylindrical also for economical reason.

- The foundation shape was determined in consideration of safety against the load of superstructure.

- The substructure is directly supported on the hard silt located 10m deep below the ground level, as a results of soil investigation.

- Results of calculation are shown in Table 6-17-13.

- Details of the shape are shown in Table 6-17-14.

- Typical drawings of the stack are shown in Figure 6-17-5.

(3) Recommendations and items to be studied

- The weight of the stack is about 20 t/m^2. In the event of attack of an earthquake the heavy load is imposed on the ground due to the overturning moment. The safety of the ground should be studied.

- Detailed soil conditions should be confirmed by investigation of soil immediately under the stack.

- Detailed structural analysis should be carried out for confirmation of soil safety.

- Necessity of pile foundations should be reviewed through the above studies.

- It is necessary to obtain permission from the aircraft authority in case the height of the structure is 180m or more. Aircraft obstruction sign and aircraft obstruction light will be provided for daytime and nighttime recognition, respectively.

- It is necessary to maintain a 4.5m height or more under the flue for the convenience of fire trucks passing.

- Pre-cast concrete piles and steel pipe piles are not available but reinforced concrete piles are produced in the factories in Bulgaria.

Table 6-17-1 List of Buildings (including the list of foundations)

		Names	No.	St.*)	Width	Length	Height	Remarks
I. List of Buildings								*):Structure
	1	Turbine hall	1	S	50.2	154.2	26.8	Including deaerator
	2	Boiler house	2	S	66.0	57.0	70.0	Including bunker and heater
	3	Central control building	1	S	24.5	43.9	17.5	Two stories
	4	Coal storage house	1	S	260.0	355.0	38.0	
	5	Limestone storage house	1	S	53.0	355.0	32.0	
	6	Tripper house	1	S	5.0	280.0	13.0	
	7	Ash treatment control house	1	RC	21.0	26.0	12.0	Two stories
	8	Coal and ash handling control house	1	RC	20.0	20.0	12.0	Two stories
	9	Water treatment house	1	S	29.0	39.0	13.0	Two stories
	10	Waste water treatment house	1	RC	20.0	30.0	13.0	Two stories
	11	Hydrogen generation house	1	RC	4.0	6.0	5.0	Roof is of steel structure
II. List of Foundations								
	1	EP foundation	2		34.0	23.0	t=1.2	
	2	Transformer found.(R1)	1		10.0	30.0	t=2.0	Main, auxiliary and starting
		Transformer found.(R2)	1		10.0	20.0	t=2.0	Main and auxiliary
	3	Exhaust gas duct found.	18		5.0	1.6	t=1.0	L=90m @5m
	4	FDF foundation	4		5.5	10.0	t=1.5	
	5	IDF foundation	4		5.5	10.0	t=1.5	
	6	Ash Storage Silo foundation	1		19.0	37.0	35.3	RC frame (2 stories)
	7	Ash Transit Tank foundation	1		19.0	37.0	29.3	RC frame (2 stories)
	8	Ash Loading Silo foundation	1		19.0	37.0	32.3	RC frame (2 stories)
	9	Conveyer found. (Coal)	125		4.8	1.8	t=1.0	L=1250m @10m
		Conveyer found. (Limestone)	30		4.8	1.8	t=1.0	L=300m @10m (240m is the existing underground tunnel)
	10	Pipe Rack foundation (Ash)	120		4.8	1.8	t=1.0	L=1200m @10m
	11	Water treatment found.	1					LS
	12	Waste water treatment found.	1					LS

Table 6-17-2 Turbine Hall

Item		Specifications	Remarks
1. Building area (m^2)		7,430.7	
	Extension	6,305.1	
	Existing	1,125.6	
2. Height		GL+27.0m	
	Extension	GL+27.0m	
	Existing	GL+27.0m	
3. Number of stories		3	
	Extension	3	
	Existing	2	Modification
4. Total floor area (m^2)		16,192.8	
	Extension	13,941.6	
	Existing	2,251.2	
5. Volume of the building (m^3)		200,629.4	
	Extension	170,238.2	
	Existing	30,391.2	
6. Superstructure		Steel Structure	
7. Substructure		Mat Foundation	Direct support
8. Exterior finish			
Roof		Concrete block with asphalt waterproof layer	Slope : 1/100
Wall	Above 2nd floor	Vinyl coating metal sheet	
	Below 2nd floor	Precast concrete panel	
9. Interior finish			
Floor		Vinyl tile (Operating floor)	
Partition wall		Hollow concrete block	
10. Others			
Building Facilities		Ventilation system	

Table 6-17-3 Boiler House

Item	Specifications	Remarks
1. Building area (m^2)	7,686.0	
For one unit	3,843.0	
Number of unit	2	
2. Height	GL+70.0m	
3. Number of stories	10	
4. Total floor area (m^2)	46,062.0	
For one unit	23,031.0	
Number of unit	2	
5. Volume of the building (m^3)	538,020.0	
For one unit	269,010.0	
Number of unit	2	
6. Superstructure	Steel structure	
7. Substructure	Mat foundation	Direct support
8. Exterior finish		
Roof	Concrete block with asphalt waterproof	
Wall	Glass fibered reinforced concrete panel	
9. Interior finish		
Floor	Concrete steel trowel finish, checkered plate and grating	
10. Others	Lightning system Elevator	

Table 6-17-4 Central Control Room

Item		Specifications	Remarks
1. Building area (m^2)		1,075.6	
2. Height		GL+17.5m	
3. Number of stories		3	
4. Total floor area (m^2)		2,466.1	
5. Volume of the building (m^3)		15,399.7	
6. Superstructure		Steel structure	
7. Substructure		Mat foundation	Direct support
8. Exterior finish			
	Roof	Concrete block with asphalt waterproof	Slope : 1/100
	Wall	Precast concrete panel	
9. Interior finish			
Floor		Vinyl tile (Control room)	
Partition wall		Hollow concrete block	
10. Others			
Building facilities		Air conditioning system	

Table 6-17-5 Coal Storage House

Item	Specifications	Remarks
1. Building area (m^2)	92,300.0	
2. Height	GL+38.0m	
3. Number of stories	1	
4. Total floor area (m^2)	92,300.0	
5. Volume of the building (m^3)	2,399,800.0	
6. Superstructure	Steel structure	
7. Substructure	Footing and tie beam	Direct support
8. Exterior finish Roof Wall	 Vinyl coating metal Vinyl coating metal	
9. Interior finish Floor	 No floor	
10. Others Building facilities	 Ventilation system	

Table 6-17-6 Limestone Storage House

Item	Specifications	Remarks
1. Building area (m^2)	18,815.0	
2. Height	GL+32.0m	
3. Number of stories	1	
4. Total floor area (m^2)	18,815.0	
5. Volume of the building (m^3)	413,930.0	
6. Superstructure	Steel structure	
7. Substructure	Footing and tie beam	Direct support
8. Exterior finish Roof Wall	 Vinyl coating metal Vinyl coating metal	
9. Interior finish Floor	 No floor	
10. Others Building facilities	 Ventilation system	

Table 6-17-7 Tripper House

Item		Specifications	Remarks
1. Building area (m^2)		1,400.0	
2. Height		GL+13.0m	
3. Number of stories		1	
4. Total floor area (m^2)		1,400.0	
5. Volume of the building (m^3)		18,200.0	
6. Superstructure		Steel structure	
7. Substructure		Footing and tie beam	Direct support
8. Exterior finish			
	Roof	Vinyl coating metal	
	Wall	Vinyl coating metal	
9. Interior finish			
Floor		No floor	
10. Others			
Building facilities		Ventilation system	

Table 6-17-8 Ash Treatment Control House

Item	Specifications	Remarks
1. Building area (m^2)	546.0	
2. Height	GL+12.0m	
3. Number of stories	2	
4. Total floor area (m^2)	1,092.0	
5. Volume of the building (m^3)	6,552.0	
6. Superstructure	Reinforced concrete	
7. Substructure	Footing and tie beam	Direct support
8. Exterior finish Roof Wall	 Ashphalt waterproof Reinforced concrete	
9. Interior finish Floor	 Vinyl tile	
10. Others Building facilities	 Air conditioning system	

Table 6-17-9 Coal and Ash Handling Control House

Item	Specifications	Remarks
1. Building area (m^2)	400.0	
2. Height	GL+12.0m	
3. Number of stories	2	
4. Total floor area (m^2)	800.0	
5. Volume of the building (m^3)	4,800.0	
6. Superstructure	Reinforced concrete	
7. Substructure	Footing and tie beam	Direct support
8. Exterior finish		
Roof	Ashphalt waterproof	
Wall	Reinforced concrete	
9. Interior finish		
Floor	Vinyl tile	
10. Others		
Building facilities	Air conditioning system	

Table 6-17-10 Water Treatment House

Item	Specifications	Remarks
1. Building area (m^2)	1,214.0	
2. Height	GL+13.0m	
3. Number of stories	2	
4. Total floor area (m^2)	2,135.0	
5. Volume of the building (m^3)	16,225.0	
6. Superstructure	Steel structure	
7. Substructure	Footing and tie beam	Direct support
8. Exterior finish		
Roof	Vinyl coating metal	
Wall	Vinyl coating metal	
9. Interior finish		
Floor	Vinyl tile	
10. Others		
Building facilities	Air conditioning system	

Table 6-17-11 Hydrogen Generation House

Item	Specifications	Remarks
1. Building area (m^2)	24.0	
2. Height	GL+5.0m	
3. Number of stories	1	
4. Total floor area (m^2)	24.0	
5. Volume of the building (m^3)	120.0	
6. Superstructure	Reinforced concrete	
7. Substructure	Footing and tie beam	Direct support
8. Exterior finish		
Roof	Vinyl coated metal	
Wall	Reinforced concrete	
9. Interior finish		
Floor	No floor	
10. Others		
Building facilities	Natural ventilation	

Table 6-17-12 Outdoor Equipment Foundations

	Name	No.	Width (m)	Length (m)	Thickness or Height (m)	Remarks
1	Foundation of EP	2	34.0	23.0	t=1.2	
2	Foundation of Transformer(R1)	1	10.0	30.0	t=2.0	
	Foundation of Transformer(R2)	1	10.0	20.0	t=2.0	
3	Foundation of Exhasut Gas	18	5.0	1.6	t=1.0	L=90m @5m
4	Foundation of FDF	4	5.5	10.0	t=1.5	
5	Foundation of IDF	4	5.5	10.0	t=1.5	
6	Foundation of Ash Storage Silo	1	19.0	37.0	35.3	RC Structure (2 Layers)
7	Foundation of Ash Transit Tank	1	19.0	37.0	29.3	RC Structure (2 Layers)
8	Foundation of Ash Loading Silo	2	19.0	37.0	32.3	RC Structure (2 Layers)
9	Foundation of Conveyer (Coal)	125	4.8	1.8	t=1.0	L=1250m @10m
	Foundation of Conveyer (Limestone)	30	4.8	1.8	t=1.0	L=300m @10m (L=240m is the existing)
10	Foundation of Pipe Rack (Ash)	120	4.8	1.8	t=1.0	L=1200m @10m
11	Foundation of Water Treatment Equipment	1	-	-	-	LS
12	Foundation of Discharge Water Treatment Equipment	1	-	-	-	LS

Table 6-17-13 Calculation of Stack Shape

Item	Unit	Ash Max	Remarks
Turbine Output	MW	230	
Temperature	°C	170	
Gas Volume	$10^3m^3N/h$	1,297.0	
	m^3N/sec	360.3	
Qg=	m^3/sec	584.6	at gas temperature
Specific gravity	kg/m^3N	1.175	
rg=	kg/m^3	0.724	at gas temperature
Required Area	m^2	17.35	Top nozzle
Diameter	m	4.700	Top nozzle
Decided Diameter	m	4.70	Top nozzle
Decided Area	m^2	17.35	Top nozzle
Velocity of gas	m/sec	33.7	Top nozzle
Diameter of flue	m	5.00	
Area of flue	m^2	19.6	
Velocity of gas	m/sec	29.8	in flue
Breached Opening	m^2	27.0	3m x 9m
Velocity of gas	m/sec	21.7	in breached opening
Specific gravity of air	kg/m^3	1.185	at 25 °C of ambient temperature
Natural draft force (Z)	mmAq	74.4	
Pressure loss (1)	mmAq	81.69	Emission loss at top nozzle
Pressure loss (2)	mmAq	22.40	Friction loss in flue
Pressure loss (3)	mmAq	18.19	Connection loss at breached opening
Total pressure loss	mmAq	122.28	
Required forced draft	mmAq	47.92	(< 50 mmAq)
Results		OK	

Table 6-17-14 Stack

Item	Specifications	Remarks
1. Height (m)	180.0	
2. Windshield	GL+177.0m	
(1) Inside diameter (m)		
Top	12.5	
Bottom	17.0	
(2) Wall thickness (cm)		
Top	25.0	
Bottom	60.0	
3. Inner flue		
(1) Number of inner flue	2	
(2) Inside diameter (m)		
Top nozzle	4.7	
General part	5.0	
4. Number of stage	5.0	
5. Superstructure	Reinforced concrete	
6. Substructure	Mat foundation	Direct support
Shape	Octagonal	
Length (m)	40.0	
Depth (m)	7.5	
7. Lining material	Castable cement lining	
8. Others		
	Lightning system	
	Ladder	

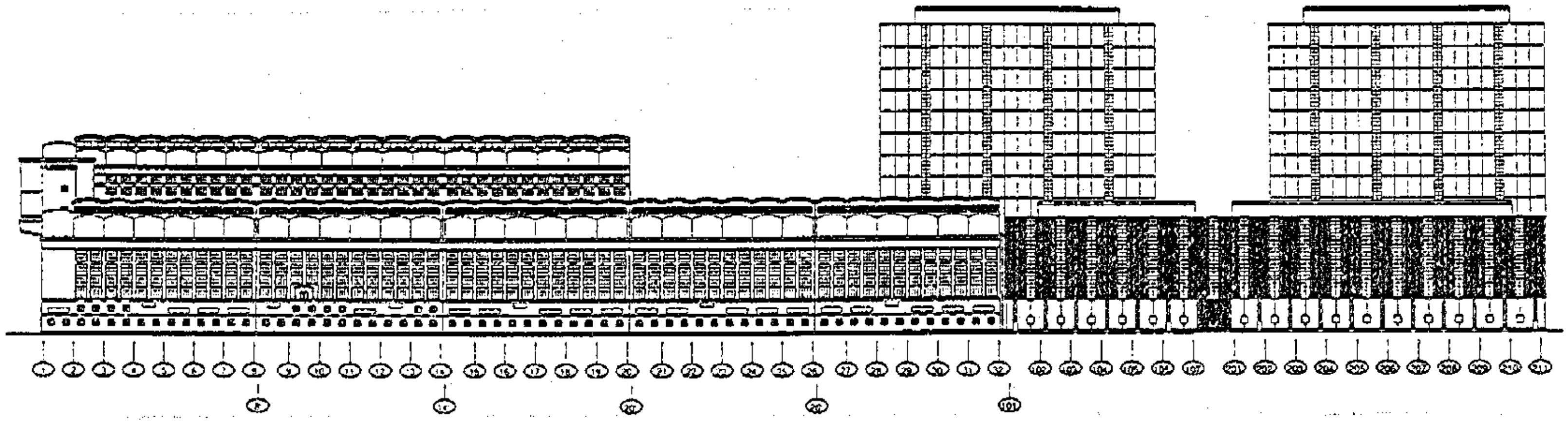


Figure 6-17-1

REPUBLIC OF BULGARIA

ELEVATION WITH THE EXISTING HALL

JAPAN INTERNATIONAL COOPERATION AGENCY

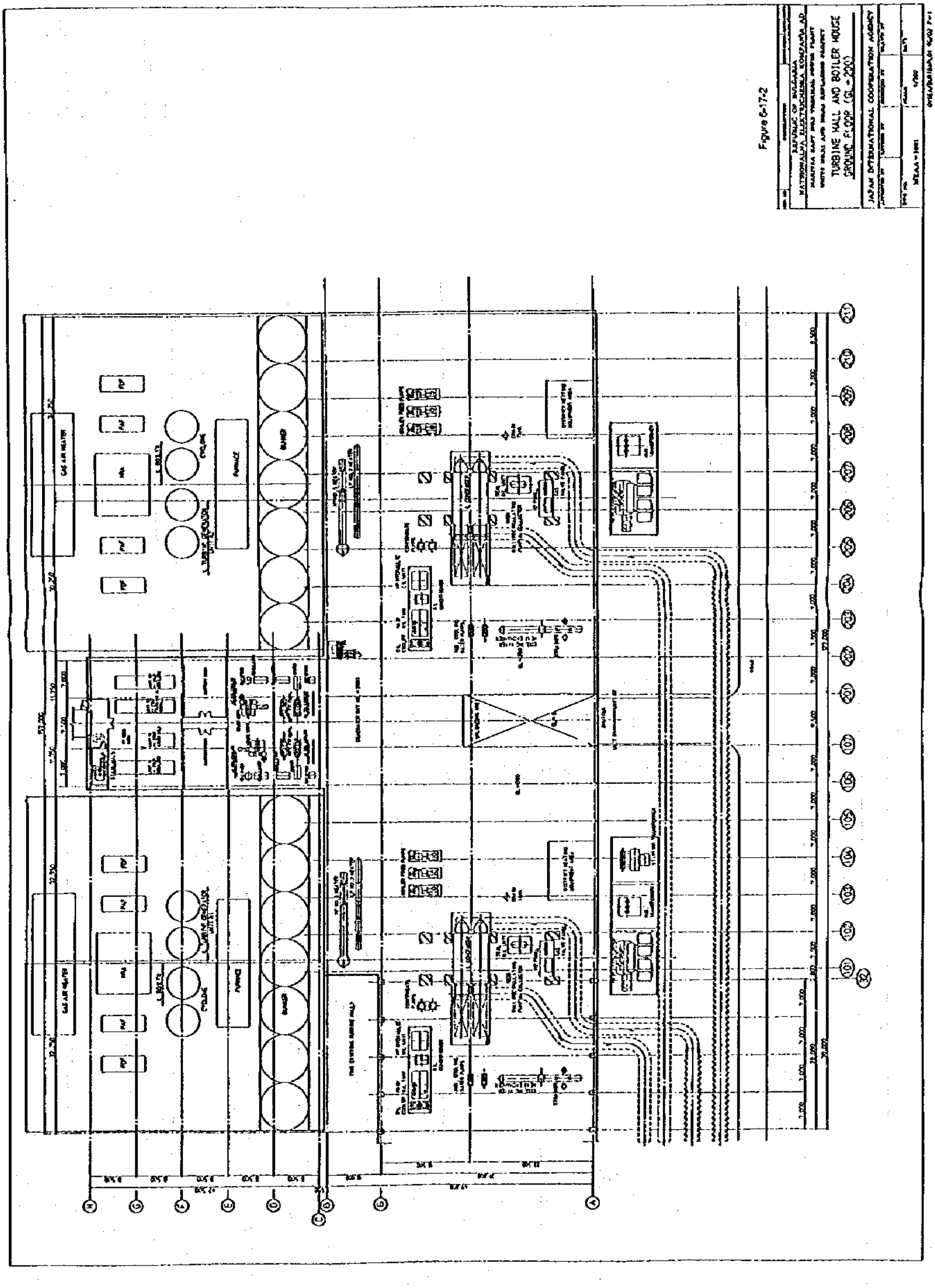
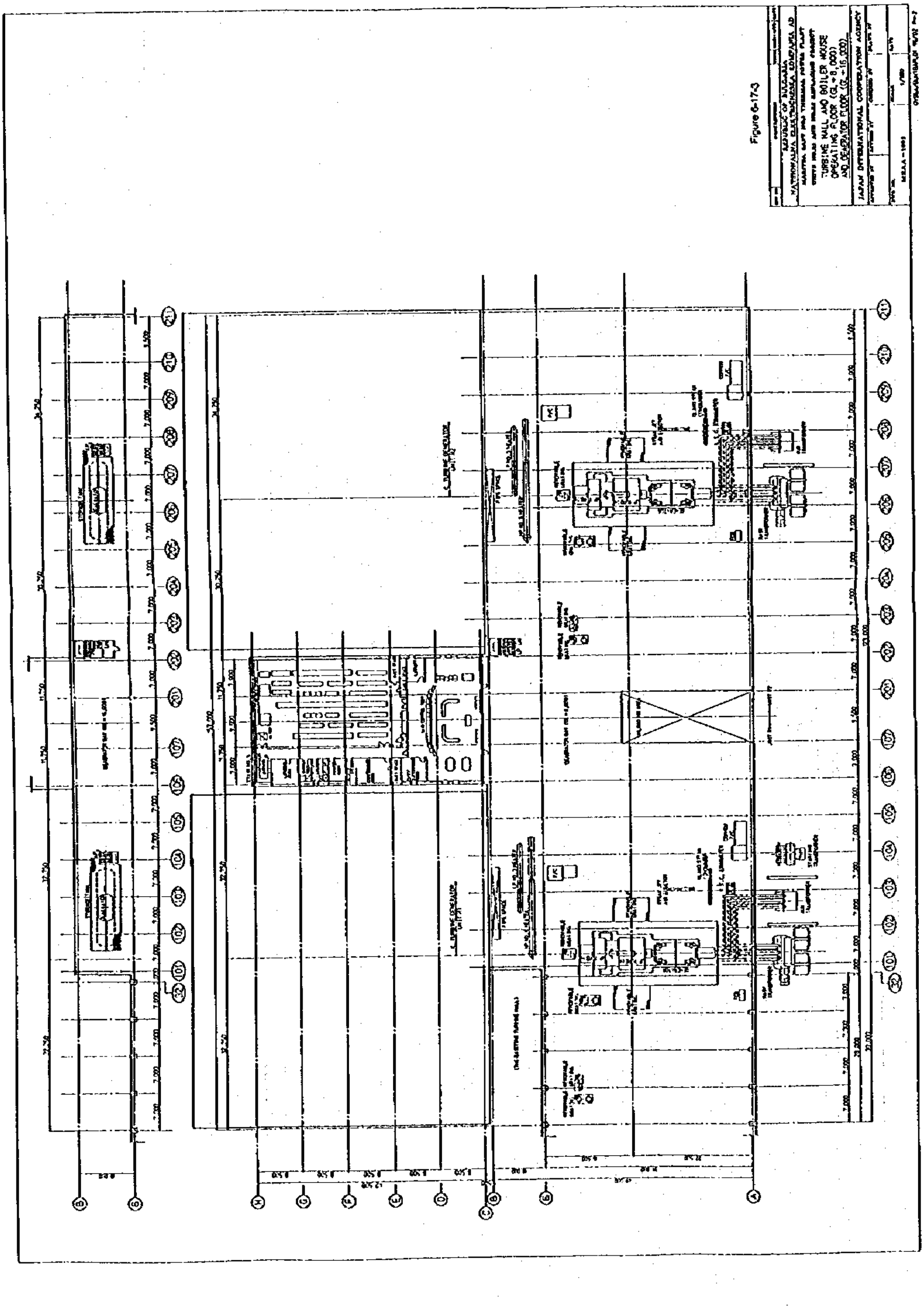


Figure 6-17-2
REPUBLIC OF BULGARIA
NATSIONALNA ELEKTRICHESKA KOMPANIA AD
TURBINE HALL AND BOILER HOUSE
GROUND FLOOR (GL + 200)
JAPAN INTERNATIONAL COOPERATION AGENCY
GAS AIR HEATER
CYCLONE
FURNACE
BUNKER



REPUBLIC OF BULGARIA
NATSIONALNA ELEKTRICHESKA KOMPANIA AD
TURBINE HALL AND BOILER HOUSE
OPERATING FLOOR (GL+8,000)
AND DEAERATOR FLOOR (GL+15,000)
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 6-17-3

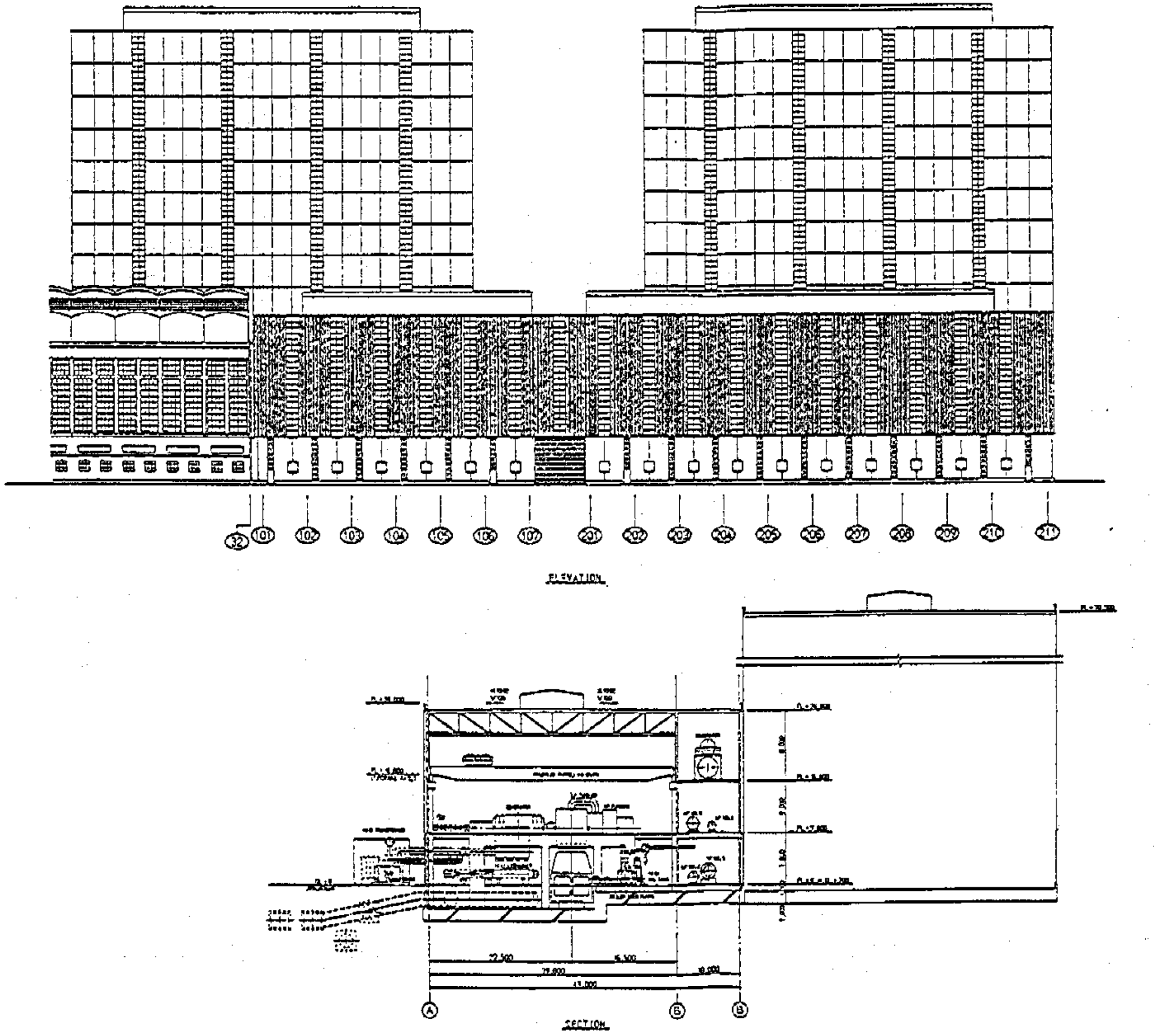


Figure 6-17-4

REPUBLIC OF BULGARIA
NATSIONALNA ELEKTRICHESKA KOMPANIA AD

TURBINE HALL AND BOILER SECTION
ELEVATION AND SECTION

JAPAN INTERNATIONAL COOPERATION AGENCY

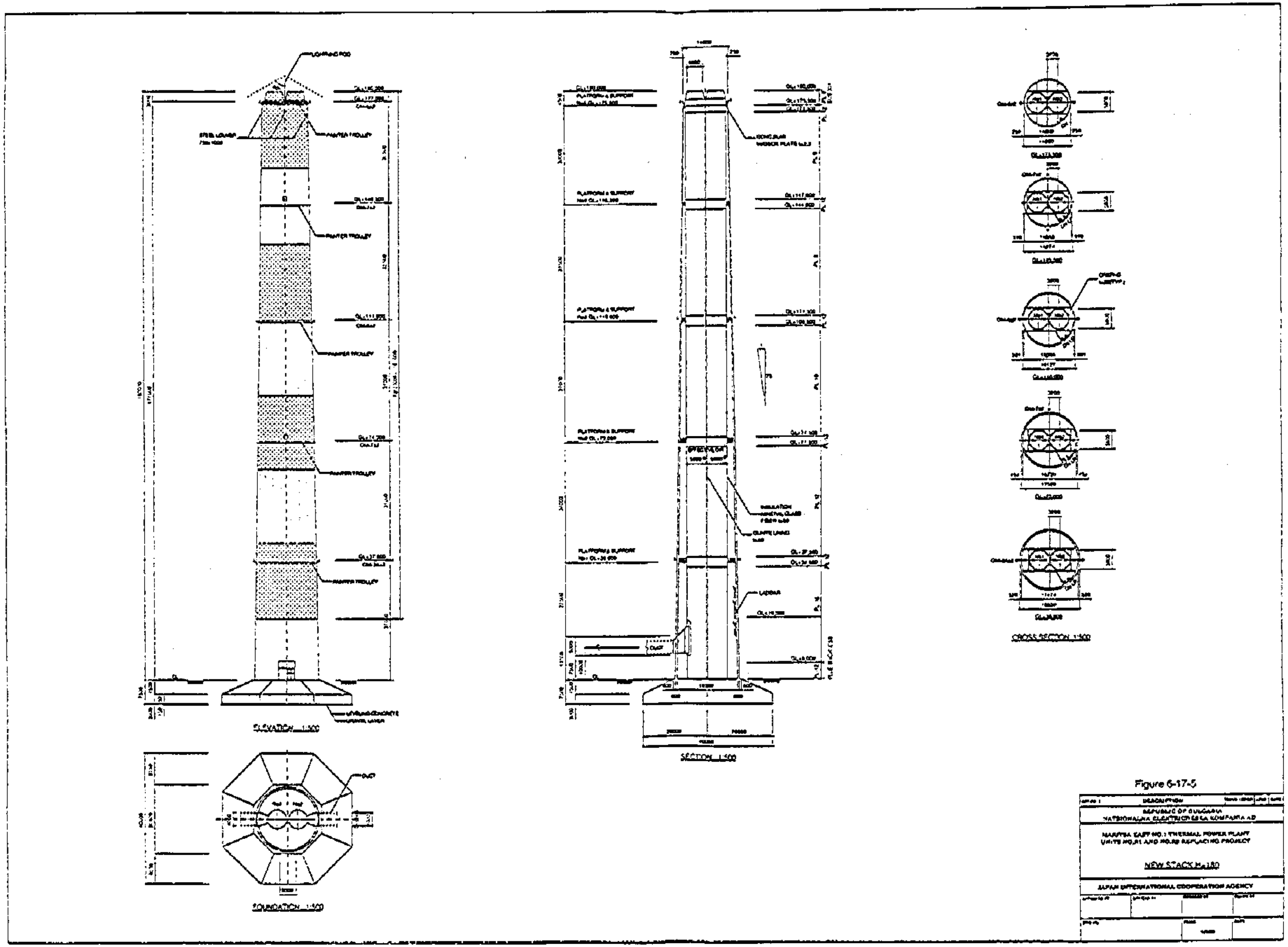

ELEVATION 1:500
FOUNDATION 1:500
SECTION 1:500
CROSS SECTION 1:500
NEW STACK H=180
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 6-17-5

CHAPTER 7. PLANNING OF PROJECT IMPLEMENTATION

Contents

Page

[List of Figures]

CHAPTER 7 PLANNING OF PROJECT IMPLEMENTATION

7.1 Contract Formation

7.1.1 Principle Concept of Contract Formation

As considered essential regardless of the scale of a project, particularly on a large scale project such as power generation project, it is of vital importance to establish its contract formation and project implementation organization in advance clearly.

Clear policy of a project formation and understanding of it at the stage of project planning enables subsequent planning to proceed smoothly.

In project implementation, there will be two parties; one is a owner, the other is a contractor who supplys equipment, devices, materials or systems to satisfy functions or performance required by the owner, within the required time period and then receives payment for them.
A contract will be settled between the above two parties, in other words they are in a position to confront with each other through (a) contract document(s).

Accordingly, it is not allowed for a party who is in a position of a contractor to play a role of a owner or to be replaced to a owner's position, even though partly.

However, in case a owner is lacking in sufficient number of personnel within his organization or does not have sufficient experiences in the fields of the associated technology or financing etc., he can employ a consultant from outside to make up for these deficiencies.

As the case may be, employment of a consultant from outside is required as one of financing conditions by (a) project cost financing bank(s) or other organization(s). In this case a consultant shall be subject to their approval.

In most of cases, when NEK implements a large scale project, a PIU (Project Implementation Unit), a kind of task force, is established within NEK and executes a function of project management on behalf of NEK. In this case, a PIU is in a position of a owner.

7.1.2 Contract Dividing

(1) There are many kinds of contract dividing practically, but two typical ones ; one is to assign a complete power plant contract to a single organization (a single enterprise or joint venture) as

a whole, which is called a full turn key contract and the other is to divide a complete power plant into plural contracts, which is called a separate contract.

(2) In the former contract, since all responsibilities consist in a single organization, it is only one contractor that a owner has to control and expedite. This formation is, therefore, very convenient to the owner.

A thermal power generation facility comprises many kinds of equipment requiring highly sophisticated technology in the diversified fields and there is no single organization in the world who can make every necessary equipment which is of the first class and cheap.

Accordingly, it is not necessarily expected to obtain excellent and cheap equipment or to introduce newly developed technology. Eventually, price is marked up.

Further, every risk hedge cost and overhead charge will be included in a offer price and eventually a contract price will be marked up.

(3) In the latter contract, there are involved many organizations which have to assume responsibilities, therefore, a owner has to control every contractor efficiently and to spend a lot of energy for technical interfacing and job coordination among contractors concerned.

Naturally, a owner have to hold managerial and technical capability required for these tasks. On the other hand, as every divided contract is settled through a process of international or domestic competition tenders, a owner can select and purchase excellent equipment with cheaper price from around the world.

(4) In this connection, contract dividing should be decided taking organically and integrally into consideration the nature of a project, required conditions, situation of the country, a owner' s capability and experience, project budget, construction period and so forth.

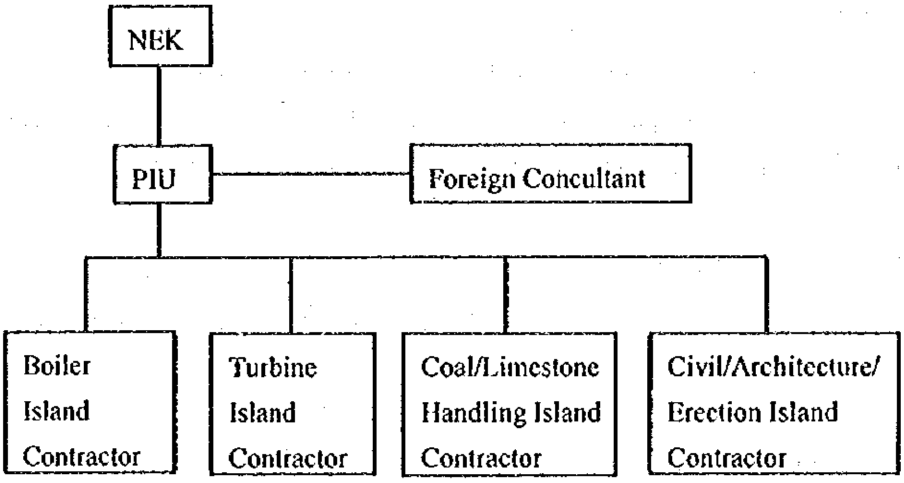
As a result of careful review of the above matters, it is recommended that a total project job to be divided into the following four (4) islands.

(a) Boiler island
(b) Turbine island
(c) Coal/limestone handling island
(d) Civil/architecture/erection island

Islands (a) through (c) covers supply of the relevant equipment and dispatch of erection commissioning supervisor(s), and island (d) includes for all civil, architectural and erection works required for islands (a) through (c).

As for scope of consultancy services, it may vary with the number of owner's personnel, owner's experience and preference, etc. but in principle covers engineering services and managerial/commercial services (assistance) in finance arrangement, tendering, evaluation, contract negotiation, project implementation and so forth.

The above contract formation can be shown illustratively as follows.



Further, the total contract cost will be divided illustratively as follows.

Consultancy Services	Civil/Architecture/ Erection Island (Civil, Erection, Design, Supply)	Boiler Island (Design, Supply, S/V)
		Turbine Island (Design, Supply, S/V)
		Coal/Limestone Handling Island (Design, Supply, S/V)

Notes: 1. S/V denotes supervisor.
2. Delivery condition: Free at site, excluding unloading

7.1.3 An Outline of Duty and Scope of Supply of Each Island

An outline of duty and scope of supply of each island is as follows. For detail, refer to "Chapter 8 Construction Cost, 8.2.1 Scope of Supply of Each Island".

(1) Boiler island

Boiler and the associated auxiliary, instrumentation and control equipment, boiler steel structure, ash handling equipment up to ash disposal yard, and technical interfacing/job coordination with other islands regarding instrumentation and control.

(2) Turbine island

Turbine/generator and the associated auxiliary, instrumentation and control equipment, district heating facility, electrical equipment, emergency diesel generator, water treatment equipment, waste water treatment equipment, substations, transmission line (limited)

(3) Coal/limestone handling island

Railway siding, coal wagon unloading facility, stacker/reclaimer, crusher, belt conveyor, and other handling facility

(4) Civil/architecture/erection island

All civil, architectural and erection works related to the above three islands and other civil, architectural and erection works, and not directly related to the above three islands but directly related to the replacing project within the premises of the power station, if any. Unloading of equipment and materials (delivered to site) from the transportation vehicles.

Demolishing works of the existing facility and subsequent land levelling works to be excluded.

(5) Consultancy services

Engineering services and managerial/commercial services (assistance) in financing management, tendering, evaluation, contract negotiation, project implementation and so forth.

7.2 Project Schedule

The following matters are taken into consideration as critical points in planning the construction schedule.

(1) Procurement of funds
(2) Selection of a consultant
(3) Basic/definite design and preparation of tender documents
(4) Time period required from tendering to contract award
(5) Civil design based upon loading data from mechanical design
(6) Check and approval procedure of drawings submitted by Contractors
(7) Construction and safety management
(8) Time period required for unit trial operation, and adjustment of system/equipment

The above mentioned items (1) and (2) are largely dependent upon NEK's effective promotion. To implement items (3)-(8), a competent and well-experienced consultant should be employed.

The construction schedule is prepared as shown in Figure 7-2-1, referring to the construction experiences gained on coal-fired power plant projects of a similar scale constructed in foreign countries. (See Figures 7-2-2 and 7-2-3.)

(1)	Completion of F/S	End of August, 1996
(2)	Fixing up of financial source (about 6 months - 1 year)	End of June, 1997
(3)	Selection of consultant	Beginning of January, 1997
(4)	Completion of basic/definite design and tender-documents	End of August, 1997
(5)	Completion of tender evaluation and contract award	
	· Civil/Architecture/Erection Island	Beginning of April, 1998
	· Boiler, Turbine and C/H Islands	Beginning of June, 1998
(6)	Commencement of civil work	Beginning of April, 1998
(7)	Boiler steel erection	Beginning of August, 1999
(8)	Boiler hydro-static test	Beginning of September, 2000
(9)	Power receiving and commencement of trial operation	Beginning of December, 2000
(10)	Initial firing	Beginning of April, 2001
(11)	Synchronizing	Beginning of July, 2001
(12)	Commencement of commercial operation (unit R1)	Beginning of October, 2001

A schedule for unit R2 will follow unit that for R1, 6 months behind.

The following points are taken into consideration in preparation of the above Figure 7-2-1.

(1) In view of the balance of electricity demand/supply in Bulgaria, commercial operation shall be scheduled to commence as early as possible, say, in the beginning of 2000s.

(2) From the technical and economical point of view, unit R-2 will be scheduled to operate 6 months after unit R-1. This will enable the highest work loads and number of workers to be minimized.

(3) Boiler hydrostatic test shall not be conducted during very cold winter season taking embrittlement of boiler pressure parts into consideration.

(4) Load restraint and shut-down period of the existing units of ME-1 to be caused by replacing works of circulating water pumps and common intake water channels shall be minimized as much as possible.

(5) The construction work in winter is expected to be carried out at the same rate as in summer. If there is seen a difficulty in construction work during very could period, time period and manner of construction work shall be reviewed.

Figure 7-2-1 MARITSA EAST NO.1 REPLACING POWER PLAN [Unit R-1 & R-2] IMPLEMENTATION SCHEDULE

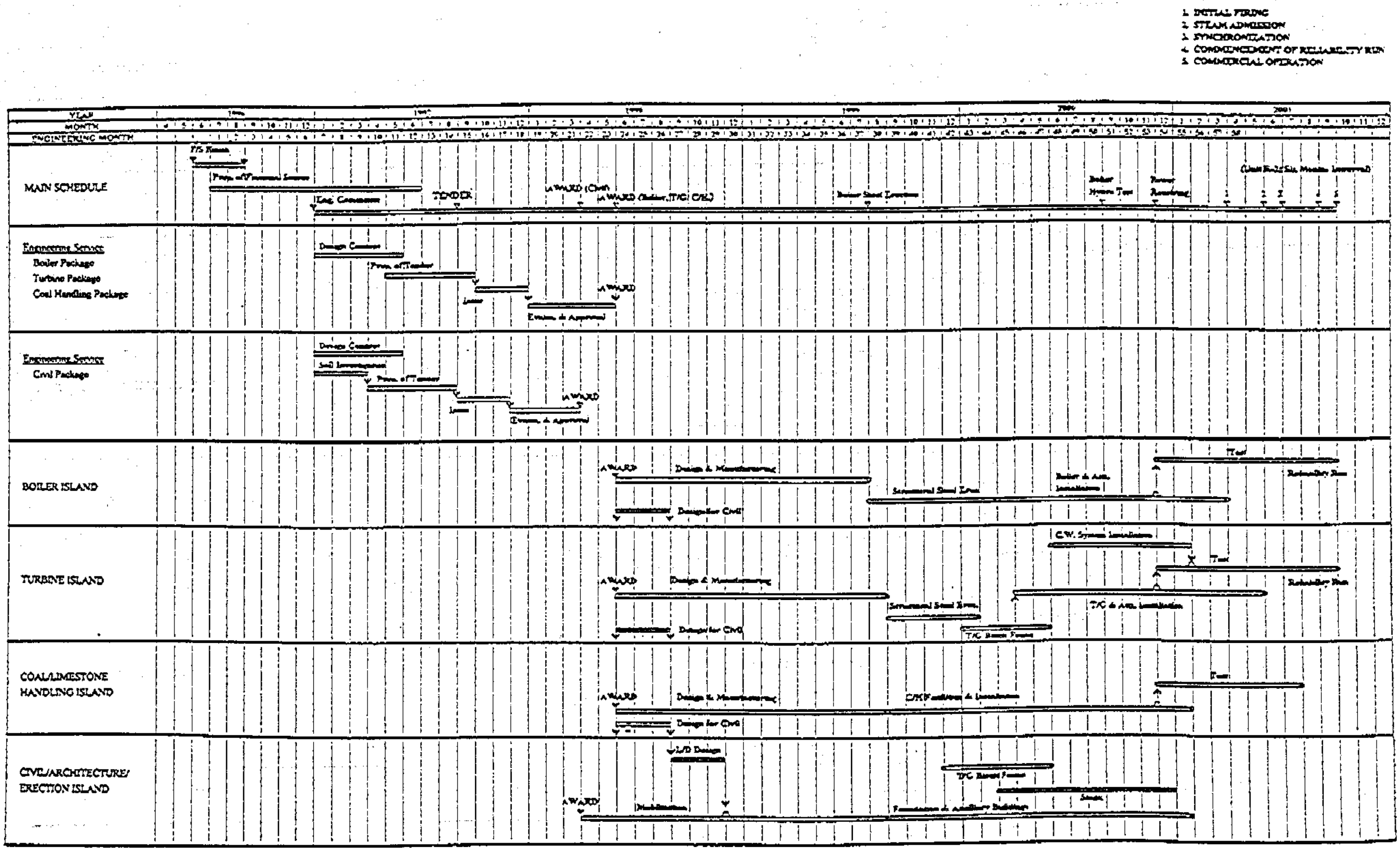
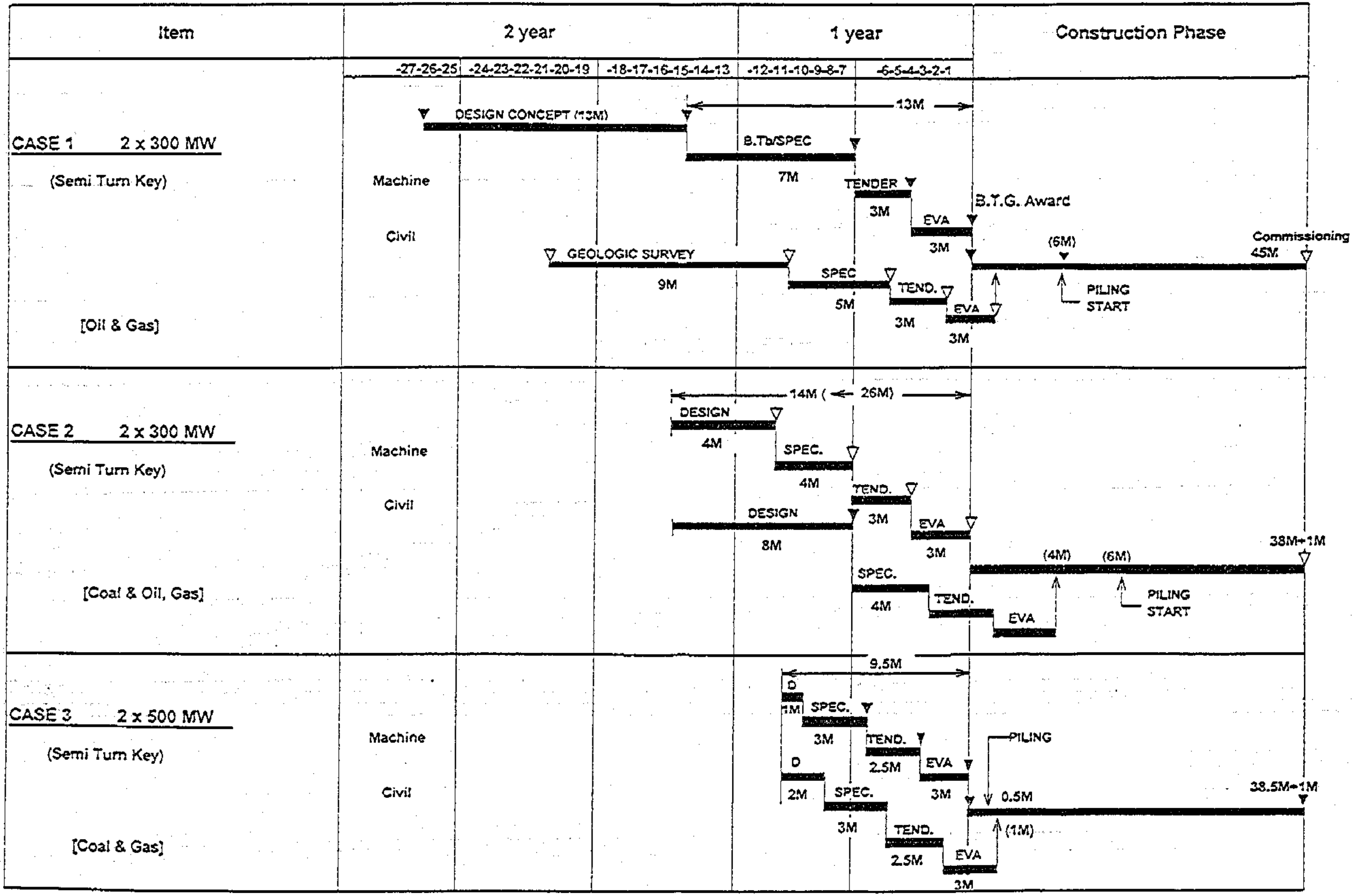
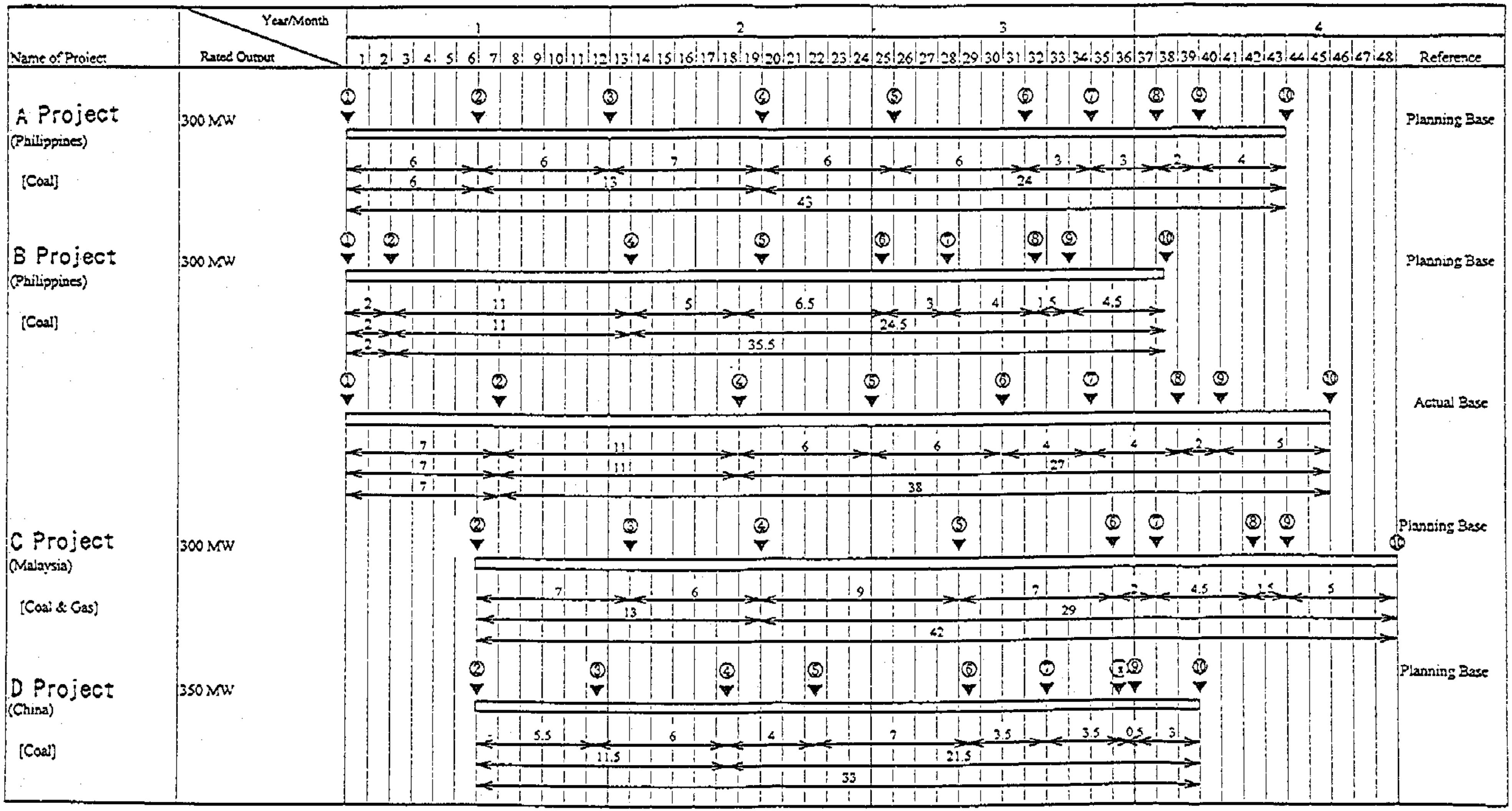


Figure 7-2-2 DESIGN STAGE (For Example)



① Award of Contract
② Civil Mobilization
③ Commencement of Civil
④ Boiler Steel Erection
⑤ Boiler Drum Lift
⑥ Boiler Hydro Test
⑦ Power Receiving
⑧ Initial Firing
⑨ Steam Admission
⑩ Commercial Operation

Figure 7-2-3 CONSTRUCTION SCHEDULE (For Example)



CHAPTER 8. CONSTRUCTION COST

Contents

[List of Tables]

CHAPTER 8 CONSTRUCTION COST

8.1 Principle Concept of Cost Estimation

8.1.1 Premises for Estimation of Project Cost

(1) A job related to project implementation is generally divided into two ;one is what is required on a owner' s side (those that a owner himself has to carry out and that a consultant has to do for assisting the owner) and the other is what (a) contractor(s) has (have) to do for supply, erection and commissioning of equipment.

As recommended in "Chapter 7 Planning of Project Implementation, 7.1 Contract Formation", the latter job is divided into the following four (4) islands.

(a) Boiler island
(b) Turbine island
(c) Coal/limestone island
(d) Civil/architecture/erection island

A island (d) covers for civil, architectural and erection works for islands (a) through (c) and those related to a replacing project.

In turn, islands (a) through (c) have to supply to a island (d) information, data and (as the case may be) design which a island (d) requires and further to dispatch competent supervisors for erection and commissioning works.

(2) Contractors for islands (a) through (c) shall be decided through a process of international competition tender, and a contractor for a island (d) through a process of domestic competition tender among Bulgarian companies.

(3) In order to minimize project cost, and to stimulate/activate industry in Bulgaria, preferably a local procurement is maximized.

It is, however, extremely difficult to tell items to be locally procured and to obtain their reasonable estimation at this stage.

Accordingly, costs of islands (a) through (c) are estimated in principle on a import basis and taking into consideration rather conservatively (negatively) a cost reduction to be attributed to local procurement.

In an actual contract, a local procurement will be thought much of and should rather be done.

A contract price of each island will, therefore, trend to be smaller than the estimated one.

As a means to give positive incentive to local procurement, it is recommended to stipulate a "local preferential clause" in the tender specification.

(4) Equipment and materials to be supplied in islands (a) through (d) shall be delivered to the site on a free-on truck basis with the relevant insurance lodged, and their unloading from transportation vehicles shall be undertaken by a island (d).

(5) The existing facilities not to be re-used in replacing project shall be demolished completely by the owner before contractors have access to the site.

In other words, the relevant demolishing cost is not included in the project cost.

(6) All taxation applicable in Bulgaria e.g. customs duty to be levied on imported goods, income tax on daily allowance to be paid to supervisors and engineers shall be totally exempted.

Taxation cost is not included in project cost.

(7) Such utility as electric power and water to be required for each contractor to execute its plant construction works at the site should be prepared and supplied to him by the owner free of charge.

(8) The project costs estimated are firm as of January 1st, 1996, not subject to adjustment and further expected to be valid for one (1) year thenceforth.

8.1.2 Project Cost Estimation Base

(1) A total project cost was estimated lump sum-wise, based upon data mentioned in a technical book published in U.S.A. as for lignite fired power plant, and based upon cost levels currently prevailing in Japan and overseas as for cost adjustment of key components.

Finally, compared with the market cost trends seen during the past fifteen (15) years, it was reviewed whether each cost is reasonable or not.

(2) In the process of cost estimation, the following items were taken into consideration.

(a) Inflation ratio in the economically stable industrialized countries.
(b) Present site conditions.
(c) Re-use of the existing facility.
(d) Cost distribution pertaining to plant key components.
(e) Cost impast of kind of fuel (change from bituminous coal to lignite).
(f) Assignment of civil/architecture/erection island to local company.
(g) Labor force cost in Bulgaria as for civil works and erection works.
(h) Items to be brought from outside Bulgaria.
(i) Exchange rate of JY100/US$

(3) A consultant fee will vary with a range of services to be covered, their contents, service duration and so on, and it is difficult to define them at this stage.

In view that in general a consultant fee is budgeted for with around 3 to 5 % of a project cost, a lump sum of 20 MM US$ was allocated for it in this feasibility study.

(4) Contingency was estimated to a lump sum of 20 MM US$.

(5) In principle, a cost to be required on a PIU side should be estimated and borne by PIU himself, and its estimation was not eliminated in this clause.

8.2 Project Cost

8.2.1 Scope of Supply of Each Island

In this feasibility, application of a circulating type fluidized bed boiler is recommended. The scope of supply of each island in this type thermal power plant is listed as follows.

(1) Boiler island

(a) Boiler proper and auxiliaries
(b) Boiler steel structure and bunker
(c) Regenerative gas air heater and steam air heater
(d) Crusher, and coal firing equipment

(e) Fuel oil firing equipment
(f) Draught system
(g) Electrostatic precipitator
(h) Piping and valves
(i) Ash handling equipment (up to ash disposal yard)
(j) Instrumentation and control (including coordination of interfacing with other islands)
(k) Electrical equipment
(l) Refractory, insulation, lagging and painting
(m) Spares
(n) Dispatch of erection and commissioning supervisor

(2) Turbine island

(a) Turbine proper and appurtenant
(b) Condenser and tube cleaning facility
(c) Circulating water pump and screen
(d) Feedwater heater and deaerator
(e) Boiler feed pump
(f) Bearing cooling system and hydrogen generating facility
(g) Turbine bypass valve
(h) District heating facility
(i) Piping and valve
(j) Generator and appurtenant
(k) Exciter
(l) Main transformer, station transformer and start-up transformer
(m) Compressed air system
(n) Emergency diesel generator
(o) Battery system
(p) Instrumentation and control equipment
(q) Electrical equipment
(r) Insulation, lagging and painting
(s) Water treatment equipment and waste water treatment equipment
(t) Switch gear
(u) Switch yard
(v) Transmission line and substation
(w) Spares
(x) Dispatch of erection and commissioning supervisor

(3) Coal/limestone handling island

(a) Coal receiving facility
(b) Coal storage facility including stacker and reclaimer
(c) Coal transportation facility
(d) Coal crusher
(e) Limestone receiving facility
(f) Limestone storage facility
(g) Limestone transportation facility
(h) Limestone crusher
(i) Instrumentation and control equipment
(j) Electrical equipment
(k) Spares
(l) Dispatch of erection and commissioning supervisor

(4) Civil/architectural/erection island

(4)-1 Civil

(a) Screen pump pit
(b) Water intake/discharge tunnel
(c) Cooling water piping
(d) Railway siding
(e) Civil works for boiler island
(f) Civil works for turbine island
(g) Civil works for coal/limestone handling island

(4)-2 Architecture

(a) Turbine house
(b) Boiler house
(c) Central control room house
(d) Ash tripper house
(e) Ash handling equipment control room house
(f) Coal storage house
(g) Coal/limestone handling equipment control room house
(h) Limestone storage house
(i) Hydrogen generating facility
(j) Water treatment equipment house
(k) Waste water treatment equipment house

(l) Stack

(m) Foundation works for boiler island

(n) Foundation works for turbine island

(o) Foundation works for coal/limestone handling island

(4)-3 Erection

(a) Erection works for boiler island

(b) Erection works for turbine island

(c) Erection works for coal/limestone handling island

(d) Unloading and storage of equipment and materials delivered to the site

(6) Consultancy services

(a) Basic planning and design of power generation plant

(b) Additional survey to be required for arrangement of technical specification
e.g. geological survey, fuel/limestone analysis

(c) Detail design

① TOR (Terms of Reference), evaluation format for PQ (Prequalification) and execution of evaluation

② Document for tendering

- Technical specification (Plant Specification, General Technical Requirement)
- Commercial specification (General Terms and Conditions, Special Conditions)

③ Assistance for execution of tendering

④ Evaluation of proposal

⑤ Assistance for contract negotiation

⑥ Assistance for project execution
e.g. time schedule control, reporting, inspection/quality control

⑦ Assistance for commissioning and operation

⑧ Assistance for supervision and evaluation of performance test

(d) Assistance for financing arrangement and control

① Prediction of disbursement

② Coordination and negotiation with financing source

8.2.2 Project Cost

A currency breakdown of project cost for a C-FBC type replacing plant is as shown below.

(Unit : MM US$)

	Foreign Currency	Local Currency	Total
1. Boiler Island	192.1	33.9	226.0
2. Turbine Island	90.1	15.9	106.0
3. Coal/limestone Island	75.7	13.4	89.1
4. Civil/Architectural/ Erection Island	62.0	82.2	144.2
Subtotal	419.9	145.4	565.3
5. Consultancy Fee	20.0	—	20.0
6. Contingency	15.0	5.0	20.0
Total	454.9	150.4	605.3

8.3 Disbursement Schedule

The disbursement schedule is shown in Table 8-3-1. The interest of during construction is allocated based on the disbursement schedule for 8% per year as foreign portion and for 10% per year as local portion.

The required fund for each year is estimated according to the normal payment terms for overseas thermal power plants as follows.

(1) Mechanical and Electrical Equipment

(a) Boiler and Turbine Island

0% in the 1st year, 40% in the 2nd year
50% in the 3rd year, 10% in the last year

(b) Coal/Limestone Island

0% in the 1st year, 25% in the 2nd year
55% in the 3rd year, 20% in the last year

(2) Civil and Architecture Works

90% at a piece rate, 10% at the time of completion.

The interest during construction (I.D.C.) is estimated as 91.9M$, which is around 15% of the project cost.

ME - 1 TPP

Table 8 - 3 - 1 Disbursement Schedule

Unit : Million US $

	1998			1999			2000			2001			Total		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
I. Direct Cost															
1. Civil / Erection Island	18.6	24.7	43.3	13.0	17.3	30.3	15.5	20.5	36.0	14.9	19.7	34.6	62.0	82.2	144.2
2. Boiler Island	0.0	0.0	0.0	76.8	13.6	90.4	96.1	17.0	113.1	19.2	3.3	22.5	192.1	33.9	226.0
3. Turbine Island	0.0	0.0	0.0	36.0	6.4	42.4	45.1	7.9	53.0	9.0	1.6	10.6	90.1	15.9	106.0
4. Coal / Limestone Handling Island	0.0	0.0	0.0	18.9	3.3	22.2	41.7	7.4	49.1	15.1	2.7	17.8	75.7	13.4	89.1
Total of Construction Cost (1-10)	18.6	24.7	43.3	144.7	40.6	185.3	198.4	52.8	251.2	58.2	27.3	85.5	419.9	145.4	565.3
II. Indirect Cost															
1. Contingency	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	3.0	20.0	17.0	3.0	20.0
2. Engineering fee	2.0	0.0	2.0	6.0	0.0	6.0	6.0	0.0	6.0	6.0	0.0	6.0	20.0	0.0	20.0
Total of Indirect Cost	2.0	0.0	2.0	6.0	0.0	6.0	6.0	0.0	6.0	23.0	3.0	26.0	37.0	3.0	40.0
Sub - Total (I + II)	20.6	24.7	45.3	150.7	40.6	191.3	204.4	52.8	257.2	81.2	30.3	111.5	456.9	148.4	605.3
III. Interest During Construction	0.8	1.2	2.0	7.7	4.5	12.2	21.9	9.2	31.1	33.3	13.3	46.6	63.7	28.2	91.9
Grand Total (I+II+III)	21.4	25.9	47.3	158.4	45.1	203.5	226.3	62.0	288.3	114.5	43.6	158.1	520.6	176.6	697.2

Final: Adm. cost not included.
Contin. 20 mil.$
Eng. Fee. 20 mil.$
IDC: F/P 8%, L/P 10%

8.4 Generation Cost

8.4.1 Estimation of Operation and Maintenance Cost

Estimated annual operation and maintenance cost for the replacing units (C-FBC, 230MW x 2u) is shown in Table 8-4-1. Conditions adopted for this cost estimation are as follow.

(1) Utility consumption of coal and limestone, etc. is based on the plant design conditions.

(2) Utility unit price is estimated on the data of NEK.

(3) Labor cost and number of personnel are as per the planning data of NEK.

(4) 3% of the construction costs is allocated for the maintenance cost.

Annual fuel cost is estimated 30,312 x 10^3\$, which is equivalent to 1.1 cent per kWh. The sum of costs for utilities (such as limestone), labor and maintenance is estimated 25,052 x 10^3\$, which is equivalent to 1.0 cent per kWh.

8.4.2 Estimation of Generation Cost

An estimated generation cost is shown in Table 8-4-2. The capital cost is 2.8 cent/kWh and the operation and maintenance cost including fuel cost is 2.1 cent/kWh. A generation cost (at sending end) is estimated 4.9 cent/kWh.

Table 8-4-1 Operation and Maintenance Cost (2 units)

Item	Quantity (year)	Unit Price ($)	Cost ($)	Note
1. Fuel cost				
Coal	2x2,526x10^{3}ton	6	30,312x10^3	• Unit price includes 1$ as development/transportation fee.
2. Utility cost				
1) Limestone	2x521x10^3 ton	7	7,294x10^3	• Unit price includes 1$ as development/transportation fee.
2) Heavy oil	660 ton	97	64x10^3	• Unit price is based on NEK data
3) LPG	80ℓ x14		307	• 20,600 Leva/year
4) Water	2x448x10^3 ton	0.0003	269	• Unit price is based on NEK data
3. Labor cost	300 persons	2,450	735x10^3	• Unit price and personnel are based on NEK data. • 164x10^{3}Leva/person ≒ 2,450 $/person
4. Maintenance cost	565.3x3%		16,959x10^3	• Construction cost: 565.3$^{M\$}$
Total of 2-4			25,052x10^3	O/M Cost
Grand Total			55,364x10^3	

Note) Annual electricity generation (at sending end): 2 x 230,000kW x 24 x 365 x (1-0.07) x 0.7
= 2,623 x 10^6 kWh

Table 8-4-2 **Trial Calculation of Generation Cost**

Item	Unit	Cost	Note
1. Total Construction Cost	M$	697.2	Project cost 605.3M$ I.D.C. 91.9M$
2. Life Time	Years	30	
3. Discount Rate	%	10	
4. Capital Recovery Factor	%	10.6	
5. Annual Capital Cost	M$	74	
6. Annual Generation kWh	kWh	$2,623 \times 10^6$	Sending End
7. Capital Cost per kWh	C/kWh	2.8	
8. O/M Cost per kWh	C/kWh	1.0	$25,052 \times 10^3$ $/year
9. Coal Price	$/ton	6.0	
10. Coal Calorie	kcal/kg	1,686	(wet, H.H.V.)
11. Thermal Efficiency	%	28.5	(wet, H.H.V.)
12. Heat Rate	kcal/kWh	3,018	
13. Coal Consumption for kWh	kg/kWh	1.79	
14. Fuel Cost per kWh	C/kWh	1.1	
15. Generation Cost	C/kWh	4.9	Sending End

CHAPTER 9. ENVIRONMENT IMPACT ASSESSMENT

Contents

[List of Tables]

[List of Figures]