5.1.3 Chemical Management

1) Water Quality Standard and Analytical Result during Unit Operation

Tables 5-5, 5-6 and 5-7 shown the water quality standards and the analytical results during operation of Unit No. 1 and Unit No. 2 of the Malaya Thermal Power Plant. The analytical results represent the daily average for the 6 months from March to August 1994.

Table 5-5 Feed Water Quality Standard Value and Analytical Value

Item \ Unit	Standard Value		Analytical Value	
	M-1 Once-Through Boiler	M-2 Conventional Boiler	M-1	M-2
Economizer Inlet Feed Water				
pH	9.2 ~ 9.4	9.2 ~ 9.4	9.2	9.2
Conductivity (μS/cm)	less than 0.3	less than 0.3	0.08	0.3
Total Iron (ppb)	less than 10	less than 10	6	5
Total Copper (ppb)	less than 5	less than 5	no data	no data
Silica (ppb)	less than 20	less than 20	10	20
Dissolved Oxygen (ppb)	less than 7	less than 7	6	6
Hydrazine (ppb)	30 ~ 70	40 ~ 70	55	56
Boiler Water				
pH	–	8.9 ~ 9.2	–	9.2
Conductivity (μS/cm) w/o passing cation resin	–	less than 20	–	9
Silica (ppb)	–	less than 200	–	63
Phosphate (PO_4) (ppm)	–	1 ~ 2	–	–

Table 5-6 House Service Water Quality Standard Value (using Demineralized water)

Item	Standard Value
pH	8.5 ~ 9.0
Hydrazine (ppm)	0.05 ~ 2.0

Table 5-7 Demineralized Water Quality Standard Value and Analytical Result

Item		Standard Value	Analytical Value
Conductivity	μS/cm at 25°C	less than 0.20	0.08
Silica (SiO_2)	ppm as SiO_2	less than 0.02	0.004

2) Water Quality Monitoring Conditions for System Water during Unit Operation

a. General

The water quality monitoring conditions during unit operation at the Malaya Thermal Power Plant are shown in Tables 5-8 and 5-9.

Table 5-8 Item and Frequency of Water Examination (Primary Treatment)

Sample	Item	M-1 & M-2
Raw Water (Deep Well Water)	pH	W
	Conductivity	W
	Silica	W
	Total Alkali	W
	Chloride	W
	Hardness	W
Filtrate Tank	pH	W
	Conductivity	W
	Silica	W
	Total Alkali	W
	Chloride	W
	Hardness	W
Demineralizer	Conductivity	D
	Silica	D
	Dissolved Oxygen	E
Demineralized Water Tank	Conductivity	E
	Silica	E
Condensate Storage Tank	Dissolved Oxygen	E
House Service Cooling Water	pH	W
	Chemical Concentration	W
Lake Water (Discharge Channel Outlet)	Residual Chlorine	W

D : Daily (every 4 Hrs.) W : Weekly

M : Monthly E : Extreme Case

Table 5-9 Item and Frequency of Water Examination (Secondary Treatment)

Sample		Item	M-1	M-2
Condensate Water		pH	D	D
		Conductivity	D	D
		Silica	D	D
		Iron	W	W
		Copper	W	W
		Sodium	D	-
		Dissolved Oxygen	D	D
Feed Water (Economizer Inlet)		pH	D	D
		Conductivity	D	-
		Silica	D	D
		Hydrazine	D	D
		Iron	W	W
		Copper	W	W
Boiler Water		pH	-	D
		Conductivity	-	D
		Silica	-	D
		Chloride	-	D
		Phosphate Ion	-	D
Main Steam		pH	D	D
		Conductivity	D	-
		Silica	D	D
Condensate Demineralizer	Inlet	Iron	E	-
	Outlet	Iron	E	-

D : Daily (every 4 Hrs.) W : Weekly

M : Monthly E : Extreme Case

As a rule, a total of 8 samples are supposed to be taken from M-1 and M-2 every 4 hours, 6 times daily, and analyzed for pH, conductivity, silica, chloride, phosphate ion, hydrazine, sodium ion and other items. Actual implementation of this, though, is less than expected.

In Japan, analysis is certainly conducted once a day, except Saturdays, Sundays and holidays. Analytical frequency is an issue which should be thoroughly reviewed.

As indicated in Tables 5-5, 5-6, 5-7, daily analytical results satisfy the water quality standard values for the most part. However, analysis of copper is not carried out.

b. Raw Water (Deep Well Water)

The plant raw water is now topped from the deep wells. Of 7 deep wells in total, 2 wells have not been used anymore. Table 5-10 shows the results of the water quality analysis of the mixed water from No. 5 and No. 6 deep wells sampled during first site survey and analyzed in Japan.

Table 5-10 Analyzed Data of Deep Well Water Quality

Item	Unit	Analyzed Data
pH	–	7.6
Conductivity	μS/cm	795
TSM	mg/ℓ	521
Suspended Solid	mg/ℓ	<2
Na	mg/ℓ	63.3
K	mg/ℓ	16.2
Ca	mg/ℓ	47.7
Mg	mg/ℓ	24.8
Total Fe	mg/ℓ	0.20
Cl^-	mg/ℓ	124
HCO_3^-	mg/ℓ	247
NO_3^-	mg/ℓ	0.042
CO_3^{2-}	mg/ℓ	<1
SO_4^{2-}	mg/ℓ	19.1
Total - SiO_2	mg/ℓ	93.9
Colloidal - SiO_2	mg/ℓ	3.2
Soluble - SiO_2	mg/ℓ	90.7

c. Demineralizer

The Power Plant has four demineralizers, Organo (27 m^3/h × 2) and Permutit (15.4 × 2). However, as the Organo supplies enough make-up water, the Permutit is not used.

When the Organo demineralizer was installed, Laguna Lake water of high turbidity was used due to insufficient deep well water for make-up water. Thereafter, since deep well water was again used after excavation, the coagulation equipment is currently bypassed. Colloidal silica, if any, in deep well water cannot be removed by the demineralizer. Therefore, attention should be paid not to allow colloidal silica to enter into feeding water.

Though an SiO_2 meter is provided at the outlet of the demineralizer, it has been out of operation for more than a year. Thus, sampling of the water and SiO_2(silica) analysis is done manually in these days. As the SiO_2 meter is an important device for water quality control, it should be repaired immediately.

The make-up resin is 5 ~ 10% per year for both cation and anion. There are 6 demineralized water tanks having 4,080-ton capacity in total.

d. Condensate Polisher

As the M-1 is a once-through boiler, a condensate polisher is installed. Operation of condensate polisher is satisfactory.

e. Chemical Injection

Injected chemicals are hydrazine (N_2H_4) and ammonia (NH_4OH) for M-1 (once-through boiler) and sodium (hydro) phosphate (Na_3PO_4, Na_2HPO_4) and hydrazine (N_2H_4) for M-2. Sodium oxychloride (NaClO) is injected in the condenser cooling water. The status of chemical injections is given in Table 5-11.

Table 5-11 Chemical Injection Status

Unit	Kind of Chemical	Injection Point	Purpose of Chemical Injection
M-1	N_2H_4 and NH_4OH	Amonex outlet	pH control and dissolved oxygen
M-2	N_2H_4	Deaerator	pH control and dissolved oxygen
	Na_3PO_4 and Na_2HPO_4	Drum	pH control and condenser leak treatment
M-1 M-2	NaClO*	After rotary screen	control organic matters

Note*: Injection method: 30 minutes/2 days
Injection concentration: 6 ppm
Residual chlorine: 0.2 ~ 0.5 ppm

3) Countermeasures against Condenser Tube Leaks

M-1 and M-2 of the Malaya TPP have both been suffering from condenser tube leaks since their commissioning. According to the 1982 JICA report, the plugged ratio for M-2 condenser tubes, for example, was 23 % (3 % for M-1) which shows how outrageously frequent the occurrence of condenser tube leaks is. Since then, leakage frequency has decreased due to changed condenser tube material and other reasons. Yet, there are still condenser tube leaks several times a year.

Unless the condenser tube leak is detected at an early stage and countermeasures are taken immediately, chloride corrodes the boiler tubes or salts generate scale in the tubes, which may cause the boiler tube to burst, leading to a unit shut-down. At the Malaya TPP, for early detection of condenser tube leaks, conductivity (cation pass) meters are installed at the condensate pump outlet for M-1 and condenser hotwell A and B sides for M-2. In addition, sampling are carried out every 4 hours for chloride ion and sodium ion analysis.

In Japan, as condenser tube leaks are rare, daily analysis of chloride ion and sodium ion is not conducted. At the Malaya TPP, it is possible to omit the daily analysis of chloride ion and sodium ion by improving the reliability of the conductivity meter (including sampling system) and by employing an alarm system. However, when the conductivity meter indicates an abnormal value, chloride ion concentration levels should be frequently analyzed and the tendency of leaks should be determined.

During first site survey, the condenser hotwell and water box return side were inspected while the M-1 was shut down. The results are shown in Table 5-12.

Table 5-12 Inspection Results for M-1 Condenser Hotwell and Water Box Return Side

Investigation Point	Results of Inspections
Condenser Hotwell	Interior was clean and judged favorably except for some foreign matters such as welding, sludge, and small tube tips were found.
Water Box (at return side)	As a large amount of vinyl, plastic, small shells, and sludge were found, the inside was very dirty. Slime had accumulated inside the tubes. (See Fig. 5-4.) As the return side is usually the cleaner side, contamination for the inlet side is assumed to be much worse.

The above-mentioned foreign matters (shells, plastic, vinyl, etc.) entered likely because of low water pressure for washing the rotary screen. Hence, the water pressure should be increased immediately. When foreign matters enter the condenser, the following troubles are anticipated.

a. If vinyl or other foreign matters clog the tube, cooling efficiency decreases and an inner-tube flow rate of other tubes increases, which may cause tube leaks.

b. A tube inlet clogged partly by foreign matter may cause inlet attack.

c. Foreign matter remaining inside the tube induces vortex, which may cause tube corrosion and leakage.

d. Shells or the like flowing inside the tube damage the inner surface of the tube, and may cause leaks.

In addition to the above, there are many factors that can cause condenser tube leaks, such as an ammonia attack at the air cooling zone, local corrosion caused by bacteria or other organic matter, and deposit attacks by slime. The sodium oxychloride (NaClO) injection, which is currently carried out, shall be investigated for its effect. Also required are a detailed investigation and study, and countermeasures against condenser tube leaks.

4) Equipment Preservation Methods during Shut-down

Corrosion prevention during unit shut-down is carried out in accordance with the preservation procedure guidelines.

Each part of the units rapidly corrodes when exposed to air during the unit shut-down. To prevent this, equipment preservation is important. During preservation, concentration of hydrazine and ammonia and N_2 (nitrogen) consumption should be recorded.

5) Start-up Water Quality Standard and Water Treatment

The start-up water quality standard of M-1 (once-through boiler) and M-2 (drum type boiler) for each stage of start-up are prescribed and actual start up are conducted on the basis of these standard.

Water treatment during unit start-up is as important as feed water treatment during operation. Thorough washing should be conducted at each step, and the next step should be approached only after confirmation that the values have been sufficiently lowered to satisfy the standards set for the current step.

For this, a sufficient quantity of demineralized water for flashing must be secured before unit start-up. In Japan, for example, 1,000 ~ 2,000 tons of demineralized water are used for unit start-up after a long-term shut-down. Also, thorough flashing is carried out, allowing 30 ~ 48 hours from unit start-up preparation to full load. Insufficient cleaning can cause deposits in the boiler tube, causing it to burst.

The water quality analytical record during start-up should be made separately from the daily water quality analytical record during operation. What should be entered in this record are the water quality analytical values for each standard for each step, along with the process of time for each step. In addition, the demineralized water consumption for the flashing should be recorded.

6) Inspections during Periodic Overhaul

Inspection during periodic overhaul is very important duty for chemists at thermal power plants. This is because the inspection results can be the final judgement of whether or not the tasks outlined in the previous pages have been properly carried out. These tasks are water quality control during operation, preservation of equipment during shut-down, and water treatment during start-up.

In a case such as silica or chloride scale deposit to the turbine blade, or the presence of excessive products of corrosion in the deaerator or in the drum, there must have been some problem of feed water treatment. This may cause the boiler tube to burst.

The points which must be covered at every periodic inspection include the condenser hotwell and water box, deaerator, high-pressure heater, flash-tank (M-1), drum (M-2), and turbine blade.

If inspection results are unsatisfactory, check all chemical control records to find the cause of the problem. Furthermore, records of each inspection (quantity and analytical data of scale, mud and sludge, observation record and photographs) should be saved and compared with the future inspection results.

7) Chemical Cleaning of Boilers

The most recent chemical clearing of the boilers at the Malaya TPP was done in May 1987 for M-1 and February 1994 for M-2. The cause of the M-2 boiler water wall tube failure was most likely hydrogen embrittlement (hydrogen damage). Hydrogen damage may occur due to the following causes:

- Condenser tube leak
- Residual hydrogen chloride from chemical cleaning

Chemical cleaning of the boilers is dangerous and, as such, requires that the job be done quickly, with well-coordinated team work and an established chain of command. The cleaning should be conducted by experienced specialists. A poorly conducted or neglected chemical cleaning may cause serious damage to the boiler. At almost all the electric power companies in Japan, chemical cleaning is entrusted to a specialized company with experience.

8) Chemical Instruments and Sampling Rack

Chemical instruments are very important monitoring devices at thermal power plants. As long as these instruments fully perform their functions, accurate data can be continuously acquired. Also, feed water treatment abnormalities, such as condenser tube leak, chemical injection abnormality or poor demineralizer regeneration, can be quickly detected, and remedied. By improving the reliability of chemical instruments, it is possible to greatly reduce the frequency of manual sampling and analysis, which is currently supposed to conducted every 4 hours by the Malaya TPP's chemical group.

For instance, the chemical group staff at an oil-fired thermal power plant in Japan (output 375 MW and 500 MW) consists of 5 chemists, who perform manual analysis and patrol of chemical instruments once a day on weekdays. They work only in day time on weekdays. The central control room has conductivity and pH recorders equipped with alarm functions, which are particularly important chemical instruments and monitored by the operators. Operations of demineralizer, condensate polisher, chemical injection, etc. are included among the responsibilities of the operators, not of the chemists.

It may not be appropriate to simply compare the chemical group and their assignments at the Malaya TPP with those in Japan. However, we believe that improved reliability of the chemical instruments should be studied in term of stable operation of units and reduced chemical operations. Operating conditions of chemical instruments at the Malaya TPP are provided in Tables 5-13 and 5-14.

The SiO_2 meter for the demineralizer has been out of order for over one year. Operational conditions of the chemical instruments and sampling rack for M-1 are satisfactory, while those for M-2 are far below standard. They should be replaced.

Table 5-13 Operating Conditions of Chemical Instruments (for Demineralized Water)

Sample Point	Conductivity	Silica	Remarks
Raw water	O	–	
Anion outlet A	O	–	
Anion outlet B	O	–	
MB-P outlet A	O	X	out-of-order since a year ago
MB-P outlet B	O	X	out-of-order since a year ago

Note: O: Existing use

X: out-of-order

Table 5-14 Operating Conditions of Chemical Instruments (for Unit System Water)

Sampling point		M-1				M-2			
		μS/cm	pH	D-O_2	N_2H_4	μS/cm	pH	D-O_2	N_2H_4
Condenser/CP outlet	Main	O	O	O	–	CP outlet O	X	–	–
	Aux.	O							
Condenser hotwell	A	–	–	–	–	O	–	–	–
	B	–				O			
Deaerator inlet		–	O	–	O	X	X	X	X
Economizer inlet		O	O	–	O	X	X	X	X
Main steam		O	–	–	–	X	X	–	–
Reheater	Hot	O	–	–	–	X	X	–	–
	Cold	O				X			
Boiler Saline (Drum)		–	–	–	–	X	X	–	–
Superreheated Steam		–	–	–	–	X	X	–	–

Note: O: Existing use

X: out-of-order

9) Fuel Oil and Lubricating Oil

The Malaya TPP uses heavy oil (Bunker C) and diesel oil (light oil). At the time of receiving, specific gravity, viscosity, calorific value and sulfur content are analyzed by API (American Petroleum Institute) methods. Table 5-15 shows the analytical results of the currently-consumed fuel oil (heavy oil) sampled during first site survey and brought back to Japan.

Table 5-15 Analytical Result of Heavy Oil

Test/Analysis Item		Unit	Heavy Oil
Characteristic Test			
	Specific gravity	15/4°C	0.951
	Viscosity	cSt (50°C)	483.6
	Water	Vol%	0.46
	Residual carbon	wt%	11.1
	Ash	wt%	0.02
	Gross calorific value	kcal/kg	10,240
Ultimate Analysis			
	Carbon	%	85.09
	Hydrogen	%	11.02
	Sulfur	%	3.59
	Nitrogen	%	0.24
	Vanadium	mg/kg	35

Heavy oil quality of the Malaya TPP is inferior to the one generally used in Japan. Specifically, because Malaya's heavy oil has high viscosity, attention should be paid to combustion. Its vanadium value is not particularly high.

By request of the operation group, viscosity, flash point, water content, etc. of lubricating oil is analyzed by API methods 3 to 4 times annually. Also, analytical data are obtained every one or two years from the government corporation, Petron.

10) Others

Approx. 14 tons/h (approx. 336 tons/day) of boiler continuous blow is carried out with M-2. This is a very large blow volume, equivalent to approximately 1.2 % of the boiler evaporation flow. The reason for requiring this large blow volume is not quite clear. It could be because, as the coagulator is bypassed, colloidal silica passes the demineralizer, increasing the silica content in feed water and necessitating the blow. In any case, as this incurs excessive loss, the reason should be clarified. If this blow is necessary, heat of blow water could be utilized for distillation of deep well water instead of demineralization with a Reverse Osmosis Plant (RO).

5.1.4 Organizations of Power Plant and Relevant Management Offices

1) *Organization of Malaya Thermal Power Plant*

a. Present Organization of Malaya TPP and Restructuring Plan

The present organization of Malaya TPP and Restructuring plan are shown in Figure 5-3 and Figure 5-4 respectively.

The outline of the restructuring plan is as follows:

Present organization	Organization Restructuring plan
- Operations	- Operations
Shift Operations-Power Plant	Shift Operations-Power Plant
Fuel Group	
Chemical Services	Chemical Services
Gas Turbine/Substation Operations	Gas Turbine/Substation Operations
- Staff of Plant Manager	Efficiency Control
Efficiency Control	
	- Staff of Plant Manager
	Safety and Quality Control (newly established)
- Maintenance	- Maintenance
Planning and Scheduling	Planning and Scheduling
Mechanical/Electrical/Instrument and Control/General	Mechanical/Electrical/Instrument and Control/General
- Support Service	- Support Service
Administration/Finance/Property	Administration/Finance/Property

a) The functional block is divided into two divisions, i.e., Operations Division and Maintenance Division.

b) The support services mainly provides support service for the entire power plant, and three sections, i. e., Administration Section, Finance Section and Property Section, are provided.

c) Operations Division

- The operations manager supports the plant manager, and controls and manages all sections and groups of the Operations Division, and also makes liaison and coordination with other divisions.

- Shift Operations is divided into Power Plant operation and Gas Turbine/Substation operation. The personnel composition is described in sub-clause 5.1.1-3) Operational Shift System.

- Chemical Service is included in the Operations Division. The personnel other than the chemical superintendent and principal chemical engineer B are incorporated in the shift duties of 3-shifts by 5-groups to strengthen chemical management.

- The operations of fuel oil receiving from barges were transferred from NPC to PPC. Accordingly, Fuel Group has become unnecessary and the group members are sent to Shift Operations to fill up the vacancy. Receiving of fuel oil to the NPC storage tank from PPC is managed by the booster pump operator of Shift Operations.

- An organization restructuring plan to transfer Efficiency Control section of the Staff of Plant Manager to the Operations Division has been proposed. This will make it possible to take quick and appropriate actions based on performance test data and operation records which are immediately acquired.

d) Maintenance Division

- The maintenance manager assists the plant manager and controls and manages all sections and groups of the Maintenance Division.

- The Planning and Scheduling Group is in charge of planning and schedule control of overhaul works.

- The Maintenance Division is composed of four groups, i. e., Electrical Group, Mechanical Group, Instruments and Control Group, and General Service Group. This Division is in charge of daily maintenance and overhaul of all power plant auxiliaries. Overhaul and repair of major equipment such as, turbine, boiler and generator are done by MSD. Condenser retubing, gas duct repair, repair and overhaul of air pre-heater and steam coil air heater, repair of dust collector, replacement of feed water heater, etc. are carried out by MSD also.

c) Staff of Plant Manager

- The table of new organization proposes to newly establish the Safety and Quality Control Group that acts as staff of the plant manager to be in charge of operations related to safety and quality control.

b. Problems on Malaya TPP Organization and Countermeasures

a) Operations Division

- The Efficiency Control Group acts as staff of the plant manager at present. So, it takes a long time for the operation group to get records of boiler performance test, boiler leak test, air pre-heater performance test, fuel consumption, vibration test, etc. It is anticipated that actions of performance management and operations management will become quick when the Efficiency Control Group belongs to the Operations Division.

- The operation manager has duties of management such as revision of operation manual, study of operations method , preparation of training plans and materials, and preparation of operation shift schedule. The operations superintendents and principal engineers of daytime duties are expected to assist in those management duties of the operation manager. The technical subjects must be studied for improvement of the efficiency and reliability of the plant through cooperation with engineers of other divisions.

b) Maintenance Division

- The thermal power plant maintenance at NPC are performed by MSD and the Maintenance Division of the power plant. MSD is in charge of overhaul and repair of major equipment, and the Maintenance Division of the power plant is in charge of daily maintenance and overhaul of auxiliary equipment.

- The maintenance works of NPC are mainly performed by its own staff. Majority of requisites of maintenance work such as maintenance staff, maintenance tools, machine tools, etc. are centralized to MSD. Accordingly, the major works of overhaul at each power plant depends on MSD conditions of available manpower for the scheduled overhaul works. Maintenance works sometimes are cannot be performed as scheduled because the planed overhaul schedule does not meet to the actual MSD capability of manpower.

- It is considered that the present organization of the Maintenance Division of the power plant is no problem. But it is necessary to study the organization and capability of MSD.

Figure 5-3 Organization of Malaya Thermal Power Plant (Present Status)

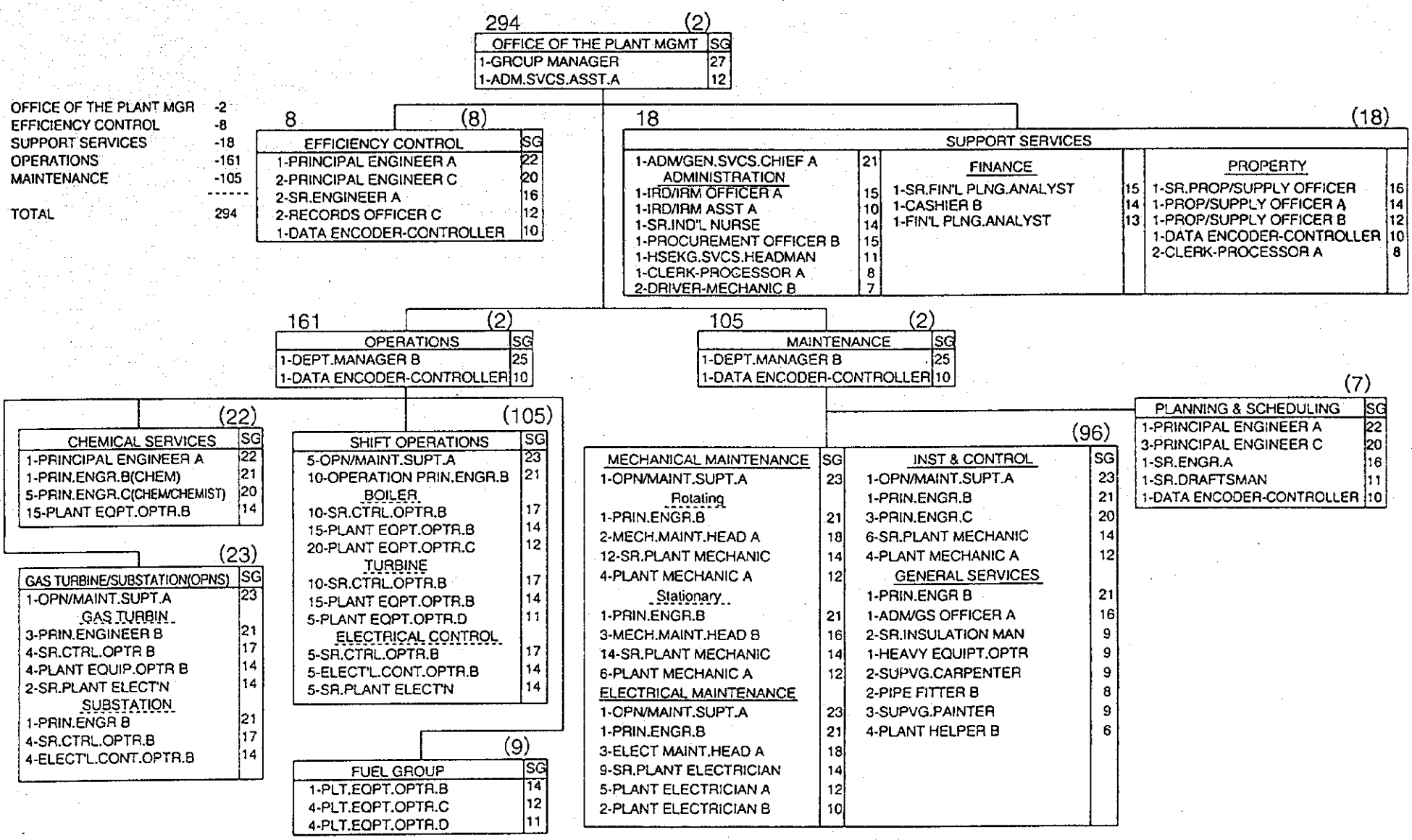
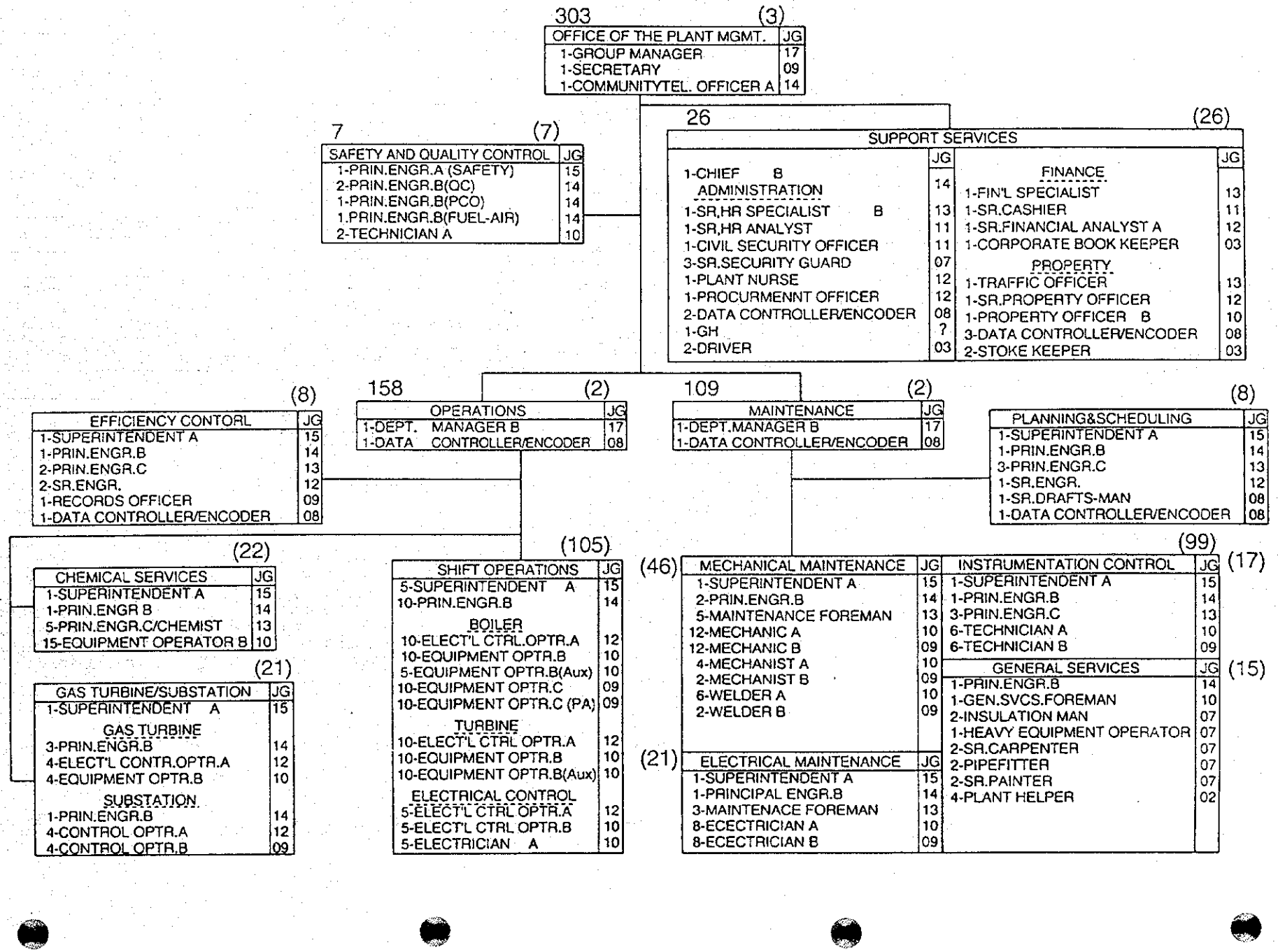


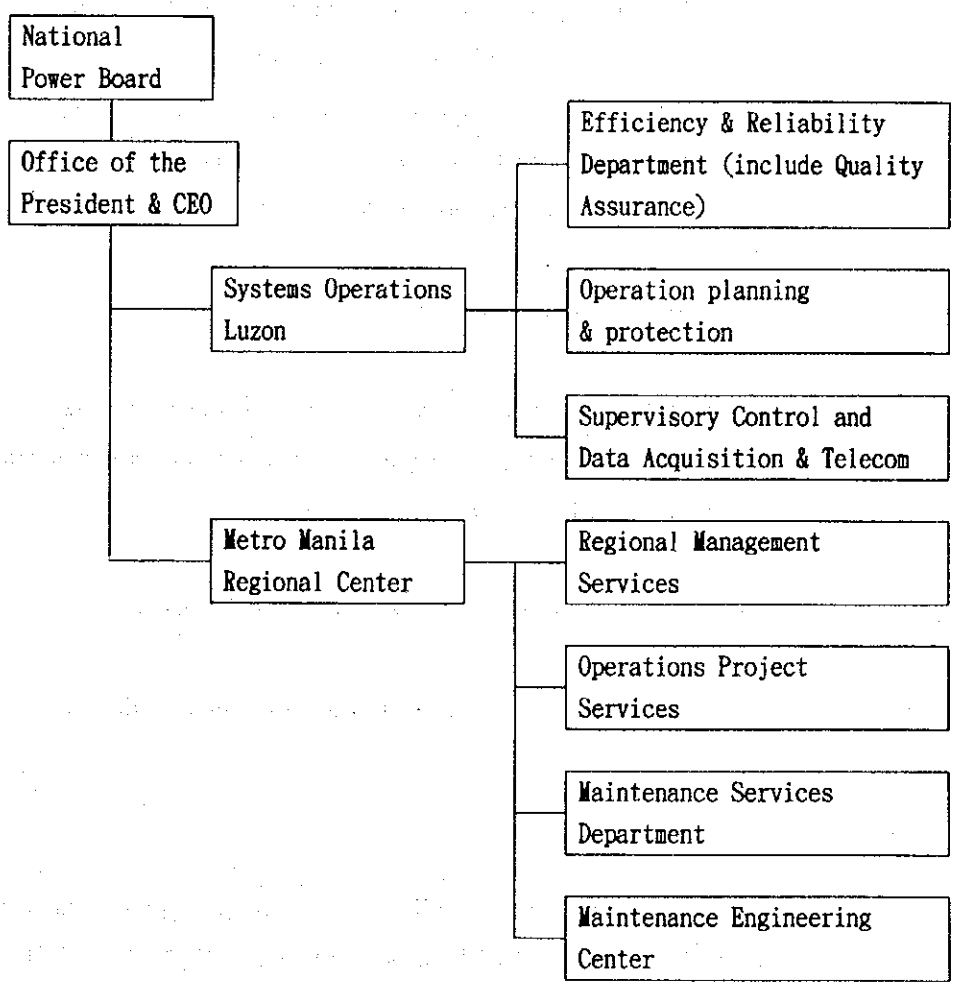
Figure 5-4 Organization of Malaya Thermal Power Plant (Plan)



2) Organization in Head Office and MMRC Related to Power Plant Operation and Management

The organization of the departments related to operation and management of power plants among the overall organization of NPC are indicated below Figure 5-5.

Figure 5-5 NPC Organization Related to Power Plant Operation and Management



a. NPC Head Office/Systems Operation Department (SOD)

This department manages operation of whole NPC power supply system, and includes the following sections.

a) Efficiency & Reliability Department (ERD) (including Quality Assurance)

This department manages and supervises power plants including the following.

- Management of plant operating status, management of performance evaluation and analysis, etc.
- Study for improvement of plant efficiency and reliability
- Guidance on performance of technical audit
- Guidance for conduct of plant performance test and diagnosis
- Monitoring of plants' troubles, outage, maintenance activities, etc., and make recommendation for power plants.

b) Operation Planning & Protection

This section performs system operation planning, and has the authorities to officially determine plant shutdown schedule for implementation of periodic overhaul at each power plant.

c) Supervisory Control and Data Acquisition & Telecom

This section controls dispatch of power from units under operation.

b. MMRC

Operation and maintenance of all of the thermal power plants in Luzon are entirely controlled and managed by Metro Manila Regional Center (MMRC). See Figure 5-6.

Operations Projects Services Dept. of MMRC (OPS) consolidates the annual overhaul schedule proposed by the power plants of MMRC and coordinate with SOD to determine the overhaul implementation schedule. In addition, OPS makes arrangement for purchase of equipment and materials required for periodic overhaul, repair, improvement of power plant facilities.

c. Maintenance Services Department (MSD)

MSD, under direct control of MMRC and independent from power plants, is a department specialized in the overhaul work. MSD implements dismantled inspection and repair of major or large size equipment such as turbines, generators, boilers, air heaters, condensers, gas ducts and auxiliary boilers during periodic overhaul works by dispatching staff to each power plant.

The overhaul works for auxiliary equipment such as pumps, fans, sootblowers and valves are carried out by the maintenance group of the power plant.

d. Maintenance Engineering Center (MEC)

MEC is now organized under direct control of MMRC. MEC was established in 1988 with objectives to maximize domestic production of spare parts and components used at power plants instead of importation and to execute examination and repair. The organization of MEC includes four divisions, i.e., workshop, engineering, quality control and support services.

3) System of Responsibility and Authorities

a. Authorities for Purchase

The authorities for allocation of annual budget including power plant repair expenses are possessed by MMRC.

The authorities for purchase of goods and works are indicated below.

100,000.peso	5,000,000.peso	50,000,000.peso	
Authority of Plant Manager	Authority of Vice President MMRC	Authority of President NPC	NP Board

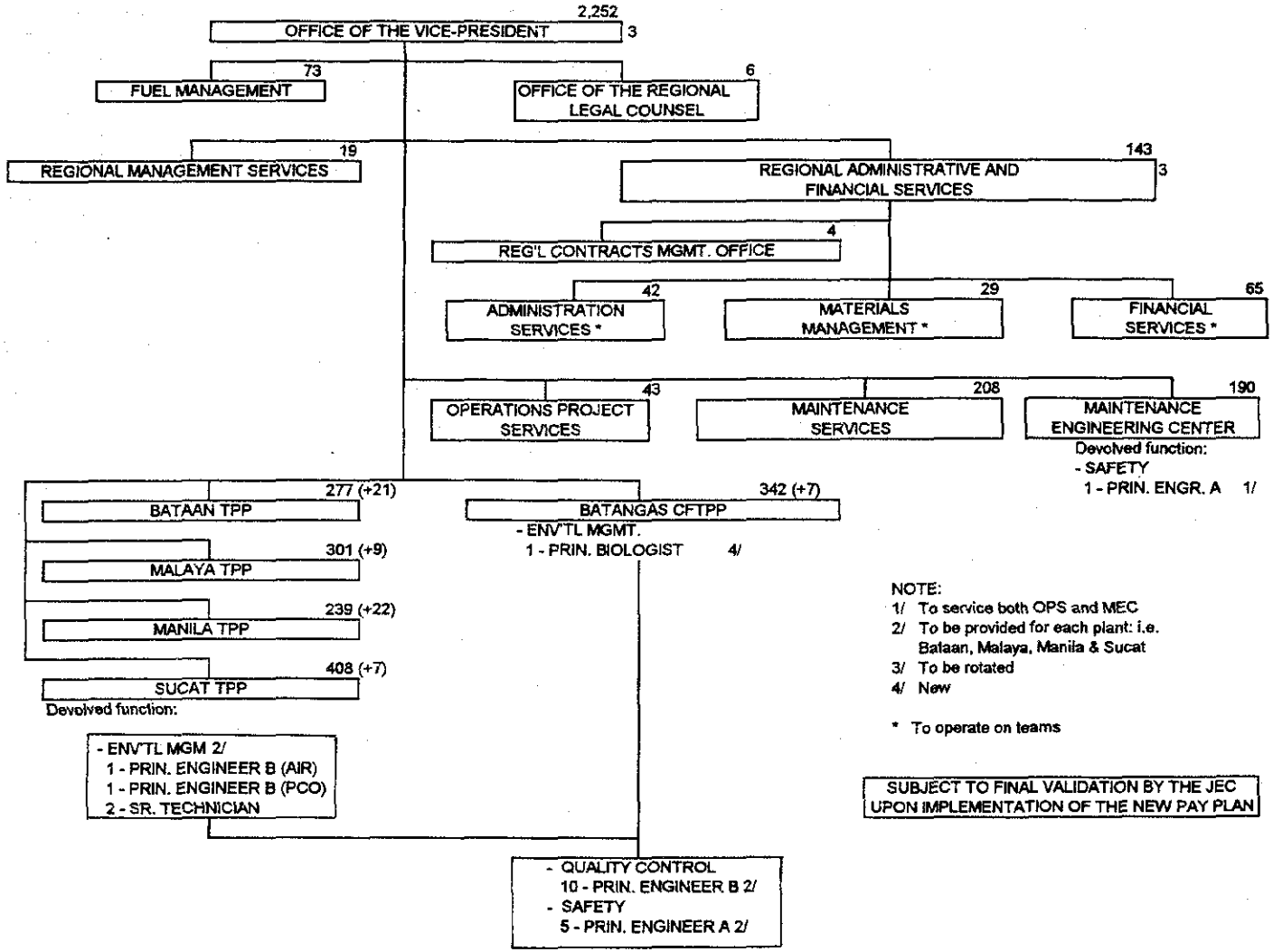
b. Right of Decision of Time of Periodic Overhaul

MMRC integrates periodic overhaul plans of power plants underneath its control, and the System Operation Department (SOD) of NPC officially makes a decision of the schedule based on the power demand and supply conditions.

Figure 5-6 Organization of Metro Manila Regional Center

SUMMARY:

OVP	-	3
FUEL MGMT.	-	73
ORLC	-	6
REG'L MANAGEMENT SVCS.	-	19
ADMIN. & FIN'L SVCS.	-	143
IMMEDIATE OFF	-	3
REG. CONT. MGMT.	-	4
ADMIN. SERVICES	-	42
MATERIALS MANAGEMENT	-	29
FINANCIAL SERVICES	-	65
OPTNS. PROJ. SVES.	-	43
MAINTENANCE SVCS.	-	208
MAINT. ENG'G. CENT.	-	190
BATAAN TPP	-	277
MALAYA TPP	-	301
MANILA	-	239
SUCAT	-	408
BATANGAS	-	342
TOTAL	-	2,252



5.1.5 Equipment and Material Procurement and Management

1) Equipment and Materials Procurement

a. Procurement System of Equipment and Materials at NPC

a) General Procurement Procedures

Procurement of equipment and materials is made at NPC in accordance with the procurement manual, which is the company regulation. The whole organization of NPC is changing at present, and even if procurement of goods and services amounting to over one million pesos, which was formerly handled by the Material Management Department of the head office, now can be handled by the Material Management Division (MMD) of MMRC.

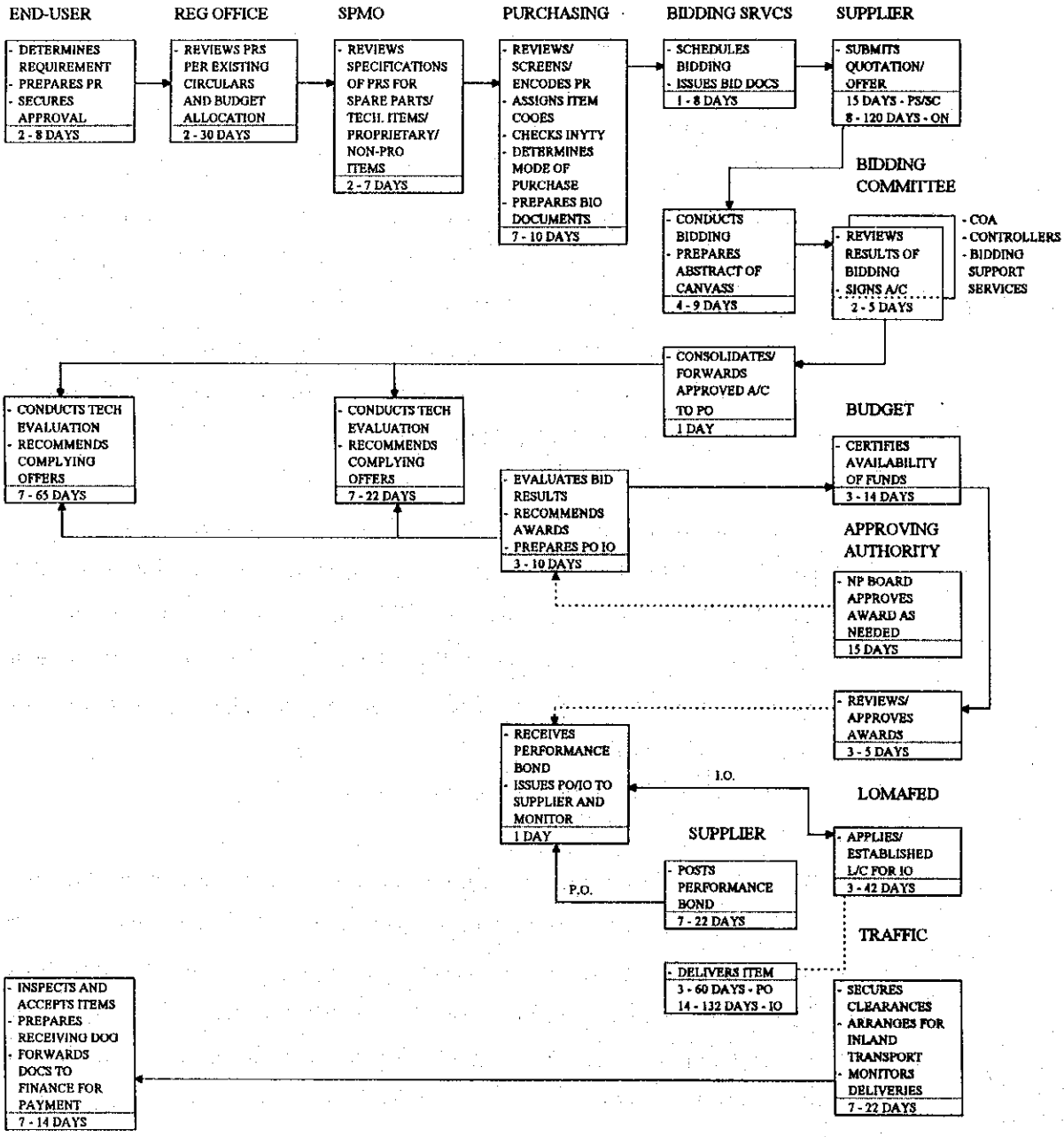
At the same time, procurement of the goods and services amounting to 5 Million pesos up to 50 million, which requires the approval of the president of NPC, including those amounting to over 50 Million pesos which requires approval of NP Board can directly be applied to the office of the president without endorsement of MMD of head office. It means that authorities of MMRC are greatly strengthened. (See Fig. 5-7)
The procurement procedures are outlined in the following.

The end users such as the mechanical maintenance group, electrical maintenance group or instrument & control maintenance group of a power plant issues a purchase requisite (PR) and obtains an approval of the plant manager (cost center head). If the scheduled amount exceeds 50 thousand pesos, the PR is sent to the Material Management Division (MMD) of MMRC. MMD obtains approval from the required level according to the purchase amount, and process the procurement as described in the following;

b) Procurement Methods

Four procurement methods namely, public bidding, sealed canvass, direct negotiation and repeat order are adopted in NPC. Besides, open purchase/indent order system is also available.

Figure 5-7 Purchasing System



b. Delivery Time

Because of the nature of NPC as a public corporation, the procurement procedures are rather complicated compared to private enterprises in general, and a longer period is required for procurement of goods. It is therefore necessary to prepare a procurement plan for procurement of parts and materials needed for maintenance and overhaul of power plant taking the procurement procedures and delivery time into account. In order to ensure the timely delivery of goods and materials, the Material Management Department of NPC specifies the standard period required for delivery of goods after the issuance of PR and informed said standard period to all department/sections concerned.

c. Preparation of Technical Specifications for Procurement of Equipment and Materials and Relevant Technical Works

Preparation of technical specifications to be appended to the PR at the power plant and relevant technical works, namely, technical evaluation of bidder's proposal, check of manufacturer's design and drawings after the contract, etc., are implemented by the end users such as mechanical maintenance group, electrical maintenance group and instrument & control group of the power plant. It is the same as power plants in Japan. Design and engineering capabilities are essential for the engineers who perform these works, and continuous harnessing of engineers having such capabilities is indispensable.

d. Inspection and Acceptance

For the articles requiring inspection at the shop test, the end user generally witnesses the said test. Acceptance of delivered goods is also the responsibility of end user.

Organizational system of NPC, which can perform the detailed technical examination on the ordered items in view of the specified quality and performance, is required.

e. Procurement Method of Components of Existing Power Plant Equipment.

Based on the past experience of NPC, it is highly risky to procure components of major equipment from sources other than the original manufacturers. Accordingly, it is considered that it is more economical to purchase genuine parts from original manufacturers even if the prices may be high to some extent.

This concept seems well understood in NPC these days, and it is clearly mentioned in item 5 "EXEMPTION TO THE GENERAL POLICIES ON PROCUREMENT" and item 6 "MODES OF NEGOTIATED PURCHASE" of Circular No. 88-34 that components of major equipment can be procured from the original manufacturers subject to the compliance with the conditions stipulated in the procurement guideline. It will be, therefore, important to maximize the effective application of these guidelines to the actual purchase of equipment parts to avoid unreliable operation of the power plant due to improper quality of the parts of major equipment.

2) Management of Equipment and Materials

a. Replacement of Parts for Major Equipment and the Auxiliaries during Overhaul

For procurement of spare parts of overhaul and maintenance, 3 years procurement plan is prepared by the superintendent of each maintenance group (mechanical, electrical and instrumentation & control maintenance group) based on the results of previous overhauls. It will be submitted to the power plant manager, and after his approval it will be elevated to the vice president of MMRC.

The criteria for listing the spare parts to be purchased are the items indicated in the instruction manual prepared by the manufacturers. The procurement plan covering all the procurement items is to be submitted two years before the overhaul. The plan is submitted one year in advance for the case of annual inspection.

The spare parts recommended by the manufacturers include consumable (such as bearings and O-rings), and all of them are procured in one package.

Review of spare part items recommended by the manufacturers seems not yet made. But the review on the items and corresponding quantity will have to be conducted to prevent excessive stocks on the basis of the frequency of the use for such consumable items as bearings, O-rings, gaskets, etc., on the basis of the operational impact to the plant for such essential parts as superheater panels, pumps, impellers, etc. and on the basis of the time for delivery as a whole.

b. List of Inventories of Warehouse

Rainwater leak was observed in the large warehouse at Malaya, which might have been caused from the entrance side. Since it will trigger corrosion and other problems of stored equipment and materials, suitable countermeasures should be taken. Further, it was found that old parts and equipment after removal for replacement (motors, cables, etc.) are shelved. Disposal of unnecessary items seems recommendable.

As for the inventory control it is being made by means of computer card. The items identified by individual tag and specifications are all shelved.

For the procurement of large-size items such as boiler SH panels, coordination between the time of delivery and work schedule is required to minimize the period of outdoor storage.

Review of the inventory standard seems not yet made. Review of the inventory standard is essential on the basis of the frequency of use, weather worthiness and delivery time of the items.

Particularly, quantity of bearings, gaskets, O-rings, etc., can be reduced if order is made before the overhaul.

c. Inventory Control Organization and System

The inventory control organization and system is such that mechanical and electrical groups have a common warehouse and chemical and instrument groups have individual warehouses with independent inventory control.

Inventory report is being made annually in October to MMRC for quantity confirmation and reporting.

5.1.6 Hiring, Education and Training of Personnel

1) Hiring of Personnel

a. Present Status

a) Hiring Policy

- NPC specifies the number of authorized positions for each section based on the approved table of organization. Filling the vacancy, if any, is a direction of National Government (Department of Budget and Management; DBM and Civil Service Commission; CSC).

- Employees of each office under the control of MMRC are hired by MMRC.

b) Hiring Plan

- The number of employees of MMRC and that of the thermal power plant as well as grade of each position are listed in the organization table. If there is a vacancy in each power plant, that power plant files a request MMRC for filling it. MMRC collects those requests, and recruits employees, when they are really needed, and allocates them to each power plant.

- Qualifications required for each position are specified in the Qualification Standards.

- Applicants for operation and maintenance who have no job experience should satisfy the following academic background:

  - Two or more years of college education in technical courses
  - Vocational school graduate or above

  * It was pointed out by NPC that one (1) year experience required for hiring a new operator is not appropriate, and NPC is trying to revise the Q. S. to allow graduate to get in as a operator even without one (1) year experience.

- Machine shop personnel and welders who have already learned the trade and craft in a vocational school are employed.

c) Hiring Method

- MMRC announces requirements, such as the number of persons to be hired, qualification, experience, and age, for each recruiting.

- Applicants shall take psychological test, and technical test at MMRC.

- The applicants for operation and maintenance job are interviewed at each power plant.

MMRC jointly determines successful applicants based on the results of tests and interview.

d) Present Status of Recruitment

According to the results of hiring from 1989 to 1994 in MMRC, the number of new employees in 1992 is 11 and that in 1993 is 175, largely fluctuates by years. Table 5-16 shows hiring record of Malaya TPP in recent years. Large fluctuation of number of hiring personnel can also be recognized.

e) Present Status of Vacancy Filling

- Ratio of existing personnel for the number of authorized positions (filling ratio)

  At present, 259 personnel are working for the authorized position of 296. So, the filling ratio is 87.5%.

  The filling ratio of the power plant operation is 88.6%, where 19 temporary personnel are included. This means those temporary employees do not have enough eligibility required for their position. To enhance capability, a continuing training program must be performed for operation and maintenance personnel.

f) Cadetship Engineer Program

NPC is to create a regular items under the office of the Vice President, at least ten (10) positions of cadet engineers. This cadets will have to undergo intensive training in the plant after which they can be absorbed to the existing vacancies at the power station. This cadet engineers shall be taken from the graduates of the existing NPC cadetship program.

Table 5-16 Hiring Record of Malaya TPP

Category		1989	1990	1991	1992	1993	1994 *2
Office	CL	-	-	1	-	-	4
Electrical	CL	11	4	1	-	12	1
Mechanical	CL	18	1	1	-	10	-
Chemical	CL	1	-	1	-	-	-
Civil	CL	-	-	-	-	-	-
Others *1	VS	1	2	-	-	11	7
Total		31	7	4	0	33	12

Notes *1: Vocational school and other courses

*2: As of June 30, 1994

CL: College level

VS: Vocational level (MIE/ECE)

b. Problems Related to Personnel Recruitment

a) Recruitment Policy and Plan

The number of authorized positions should be reviewed and recruitment policy should be changed considering the following problems:

- It is not desirable that the number of recruited persons frequently and substantially changes by year. The reasons for this are as follows:

It takes at least five to six years for operation and maintenance personnel to get sufficiently skilled. If a lot of graduates or unskilled persons enter the power plant at a time, the entire technical level drops. And, it also causes difficulty of their promotion. In future, when they leave the power plant simultaneously, a substantial number of vacancies should be filled again. In this way, fluctuation of the number of persons adopted causes also difficulty in personnel management. It is not desirable to change this number also from the viewpoint of planning education and training.

From the above points, it is expected that the number of persons to be recruited per year is to be unified as far as possible. To do this, employment plan must be studied and formulated on a long-term basis.

b) Recruitment Method and Condition

- To fill vacancies, it takes three to four months according to the present procedure. When many persons must be recruited, recruitment shall be made five to six times a year and amount of work required for the procedure, including staff and time, also increases.

- The power plant must provide orientation and basic technical education for new operation and maintenance personnel. This is common agenda to each power plant. So, this may be appropriate that those programs are given by collective training. Each power plant hopes so, too. However, it is not easy to provide collective training with the present recruitment method based on the present recruitment guideline. From this point also, it is desirable to recruit personnel once a year and the number of persons to be recruited is unified for each year.

- Job interviews for operation and maintenance of power plants are being done by not only superintendent in charge but also the manager in charge.

- It may be reasonable that the primary evaluation for recruitment is made according to the results of technical test and job interview at MMRC.

2) Education and Training

a. Present Status of Shift Operations Section

a) Collective Training of New Employees

Collective training, for example orientation or basic education done in one place together for all the employees, is not done for persons newly employed by MMRC before starting work. New employees are directly sent to each position in the power plant and undergo the on the Job Training.

b) Position Training of Operators

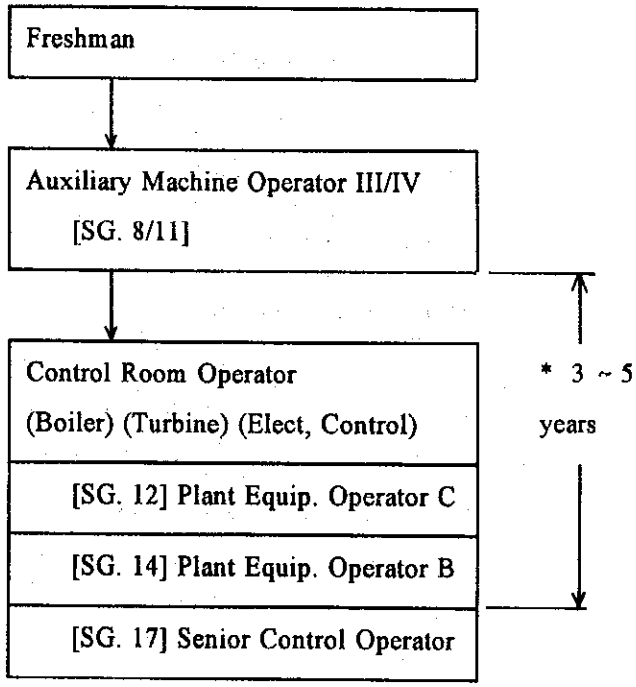
Policy of Position Training

When a certain operator leaves from a position, to fill a vacancy, it is necessary to change the other operator's position. At that time, candidates appointed to a position to be filled must satisfy requirements of the present Qualification Standards (QS). So, candidates are selected from those who have one to two years of relevant experience about a position to be filled. Selected candidates perform at least minimum training specified in the QS. If operators of boiler, turbine, and electrical control hope to learn the other positions than their present positions, their application is accepted.

Promotion and Number of Experience Years of Operators

Operators learn their positions in the following steps and promote as follows.

Promotion of Operators



* Normally, it takes three years or more for the college graduate to promote from auxiliary machine operator to senior control operator, and five years or more for the vocational school graduate. The actual number of years necessary for the promotion is depend on personal ability and/or availability of vacant position.

Servicing period and position training

According to the QS, minimum servicing period of each position is as follows:

Position Title	Number of minimum experience years in the same position
Aux. Machine Operator	3 years
↓	
Plant Equip. Operator C	1 ~ 2 years
↓	
Plant Equip. Operator B	2 years
↓	
Senior Control Operator B	3 years

It is required for operators not only to improve their skills for the present position but also to learn further skills and to take training toward the next step by OJT during the above period. This is necessary also for a smooth rotation or promotion in the operations division.

b. Problems of Operators Training and Its Solution

a) Collective Training for New Employees

At present, collective training for new employees is not performed in NPC. Collective training for new employees is one of the most important subjects as described below.

Collective training has the following two purposes:

- Guide new employees to understand their roles and mission as employees of NPC and have basic mental attitude of members of the society and organization

- Guide new employees to learn basic knowledge and skills so that they can easily acquire the skill within short period after assigned to each position

Every supervisor of each position admits the necessity of training for new employees. This agenda should be discussed not only for new employees recruited by MMRC, and it cannot be solved by MMRC only. The NPC Head Office will be to determine the policy of receiving action and implementation plan.

The present agenda to be studied is as follows:

The new employees recruited by MMRC will be better to be trained in groups at the venue within the control of MMRC with the support of NPC Head Office.

Example of Collective Training in Japan

Items		Example in Japan	
Forecasting the number of persons to take training:		Recruitment is done once a year on a regular base. All the persons recruited that time (including the college graduate and high school graduate) take collective training. For the thermal department, 40 to 50 persons are expected.	
Preparation of the venue and facilities:		A training center with a dormitory is provided.	
Arranging lecturers and training materials:		The human resources and the training center take in charge of this.	
Period:		Three months after entering the company (April 1, every year) (Thermal department)	
Securing the required budget:		The personnel department secures the budget.	
Details of education	Fundamental education (common education)	Consciousness and attitude	Transferring from the student life to the life as a member of the society and raising the consciousness of a member of the society and organization
		Knowledge and skills	Giving knowledge related to the electric utility company and the skills/basic manners of proceeding job
	Special education	Giving specialized knowledge and skills by OJT widely required for the services	

Note: Text books are prepared for new employees.

b) Training for New Employees in the Power Plant

A collective training mentioned before is not being conducted by MMRC or NPC head office. Therefore, the power plant must conduct it. New employees start OJT as auxiliary machine operators, the first position, immediately after being employed by the company. It is desirable that the fundamental education mentioned before (common education and fundamental special education) is done during OJT, but it may be difficult to ask a trainer in charge of new employees

for fundamental education in addition to OJT because he might have never undergone collective training. It seems however, that the fundamental education can be supported by the power plant to some extent.

Example in Japan

New employees: All the new employees of the technical sections recruited for the thermal power department undergo education as operators. This is the company policy. So, all the new employees of the technical section are assigned to the operations section in the power plant. In future, some of them may move to the maintenance section or other section, or the other power plant or head office.

Schedule: Training period of new employees in the power plant is 6 months. After that, they become patrol personnel formally.

Details of training (during 6 months training):

- Overview of the entire power plant facilities
- OJT as patrol* personnel (for all the units)
  - * This may be equivalent to the NPC's auxiliary machine operators. However, the patrol personnel are positioned in the central control room, which is different from the NPC's operators.
- The operation manual is used as a text book.
- New employees are provided with text books (also used for collective training).

Table 5-17 Training Schedule

	April to June	July to December	January to March
Collective training in the training center	3 months ← →		
OJT in the power plant		9 months ← Training for 6 months →	Patrol personnel for 3 months →

c) Promoting the Operators Training (Position Training)

The staff fill up ratio of the Shift Operations of Malaya TPP as of July 31, 1994 is 72% with permanent staff, and there are 19 temporary operators. When the temporary operators are taken into account, the fill up ratio is 88.6% (See Table 5-35). These temporary operators are apprentices, as it was, and they need position training. The position training should be strongly promoted especially for the operators below Senior Control Operators because almost all of them have not learned multiple positions as mentioned in the foregoing clause of "Characteristics of the Operations Division".

It is desirable that the position training for operators is performed based on the basic policy regardless of needs to fill the vacancy, and all the operators learn multiple positions. If the same operator work in the same position for long time, it leads to demoralization.

At present, the thermal plant operator training is performed as the result of filling the vacancy generated by retirement, etc., or by a request from an operator. This is not sufficient and should be improved. The operators training should be performed based on the basic policy common to each thermal plant. The basic policy should be determined through a meeting of the human resources group of the head office, Regional Office and the thermal power plant.

Although there are already existing training program for operations personnel, these training should be given at regular intervals and should be synchronized with the training of new operators.

d) Job Rotation

Job rotation should be performed for the operators within the learned positions for improvement of their ability.

Example of job rotation in Japan

Operators learn three positions, boiler, turbine, and electrical/control positions, by OJT in principle. The operators change assignment within the learned positions by a certain period and interval. This is called job rotation, which is performed

regardless of operator's retirement or shifting.

Job rotation is done for the following three purposes:

- Giving wider knowledge and experience of job
- Giving equal opportunity of promotion
- Facilitating filling a vacancy

So, job rotation is advantageous for both company and operators.

e) Operator Training for Skill Improvement and Trouble Shooting

Plant operation without forced outage is mainly dependent on prevention of operational errors. Suitable timely operation at abnormal condition of the plant is particularly important.

It is the best to make use of an operation simulator for trouble shooting training.

We were informed by NPC that a simulator will be installed at Batangas TPP as a part of the construction project of the No. 2 unit.

It is ideal that staff training facility with lodging (to be also used for collective freshman training) will be constructed, and an operation simulator will be installed at this training facility. Such facility are needed for fast developing of young operator's skill to the capable level and also for promotion of trouble shooting training of all operators.

f) Needs of Training for the Operators

- Large number of engineers moved to Saudi Arabia from NPC between 1988 and 1990. To fill resulted vacancies, NPC was obliged to recruit many new employees at one time. Most of newly recruited employees were assigned to the operation and maintenance divisions. Employees up to now, including those recruited between 1988 and 1990, have got some training but, those are not enough, and the recent training that's being provided are fundamentals of power plant operations starts in Bataan TPP. The some training will soon be given to other thermal power plants.

- JICA submitted the report about the rehabilitation/renovation and operation/maintenance improvement of the power facilities in Luzon Grid (so called, Rehabilitation Master Plan Study) in May 1992. In this report, JICA pointed out that the education and the training for a large number of new employees are important tasks in the future, and suggested the following two actions;
  - Let the leading operators in the company gain more knowledge, improve skills, and get more experience of operations
  - Improvement of the education and the training for new employees

- JICA emphasize that the above ideas suggested two years ago are still applicable considering the present condition of education/training for operators.

- Five to six years have passed since large number of employees were recruited between 1988 and 1990. Of them, operators who rapidly promoted are now Plant Equipment Operators B or C, who bear the destiny of the operations division.

The NPC management also recognizes that promoting training for those mass recruited employees is important and plans its implementation.

First priority is given to employees recruited between 1991 and 1993.

Second priority is given to employees recruited between 1988 and 1990.

In addition, training programs for technical engineers and managers & supervisors have already been prepared.

g) Operator Training Plan

Plant operation without forced outage is mainly depends on the prevention of operational errors. Proper operation for trouble shooting of any abnormal situation is particularly important.

Countermeasures

The countermeasures to be taken by NPC to minimize operator errors have two aspects indicated below:

- Training using an operation simulator
- Evaluation of skill and experience of operators

Case of Japan

The points of general principles of operator training in Japan are as follows.

- To conduct position training in the second and third years after entry to the company, and;
- To conduct operator training using thermal power plant operation simulators in the second year after entry to the company.

The operator training using thermal power plant operation simulators involves four courses.

In addition, self-learning simulators (personal computer type) were developed and are used for self-initiated training at thermal power plants.

- To make all operators (of the third year after entry to the company) to attend thermal power plant fundamental skill training.
- To make senior operators to attend courses including safety control and quality control out of thermal power plant maintenance technology training.

c. Current Situations of Maintenance Division

a) Freshman Collective Training

No collective training, but only O. J. T. is conducted like the case of operators.

b) Training of Maintenance Staff

When the position of a certain maintenance staff becomes vacant, the necessity to change positions of some of maintenance staff arises.

At this occasion, the candidate to be appointed to the position to be filled up should satisfy four conditions specified in the current Qualification Standards (QS). The candidate, therefore, is selected out of those staffs having experience of 1 ~ 2 years relevant to the position to be filled up.

Training is applied to the selected candidate for the length of time specified in QS as the minimum requirement.

d. Problems in Training of Maintenance Staff and Countermeasures

a) Freshman Collective Training

No collective training is conducted like operators. Since the objective and necessity of collective training are same as those for operators, freshman training should be applied to both of operators and maintenance staff at the same time.

b) Training of Newly Employed Maintenance Staff at Power Plant

The reliable operation of power plant without forced outage depends on the achievement of Maintenance Division.

As already mentioned in the section of promotion of operator training (position training), the permanent staff sufficiency ratio of the Maintenance Section (maintenance group) varies group to group between 73% and 97.6% as of July 31, 1994. Two casuals each are included in mechanical group, electrical group and instrument & control group respectively. The staffs of every age group need

training as well as young and new employees having little experience in the maintenance.

Case of Japan

Since the maintenance work at field is implemented as consigned to a professional contractor in Japan, the circumstances related to training of maintenance staff are entirely different from those at NPC. Even under these circumstances, however, such training that is indicated below is conduced at the staff training center and also outside of the company.

Table 5-18 Training for Maintenance Staff

Course	Contents of Training	Object
Thermal power plant fundamental skill training 3 ~ 4 times a year, 5 days each time	- Knowledge and practice with pumps and valves - Fundamentals of maintenance and practice of welding	Maintenance staff of experience in maintenance up to 3 years
Thermal power plant maintenance technology training 3 ~ 4 times a year, 5 days each time	- Knowledge on accounting and on engineering and estimate - Process control and non-destructive examination - Safety control and design criteria	Maintenance staff
Manufacturers' technology training Once a year, 5 days each time	Boiler, turbine, generator, computer, relay, control technology, etc.	Maintenance staff

5.1.7 Summary of Software Problems

1) Operation & Maintenance Procedures

- Preparation of complete operation manuals and maintenance manuals
- Start of OMP project - preparation of Operating Procedure
- Preparation of operation manuals by MMP project
- Improvement of residential facilities and commuting method
- Review on chemical management

2) Daily Patrol and Inspections, and Routine Work

- Revision of item and frequency listed in Monthly Routine Sheet and Routine Patrol Check Sheet
- Review of item and frequency listed in Preventive Maintenance Work Order

3) Planning of Overhaul and Preventive Maintenance

- Review of planning and preparing methods for overhaul
- Thorough overhaul of equipments
- Taking the safest measure for procurement from foreign countries
- Inspection of secular deterioration and preparation of long-term inspection schedule
- Implementation of remaining service life diagnosis
- Arrangement of overhaul records

4) Overhaul Procedures and Implementation Structure

- Making overhaul management system explicit
- Completion of overhaul procedures
- Transfer the overhaul procedures of MSD portion to MMP (standardization)

5) Management of Drawings and Data

- Refinement of process in the drawing/document management center.

6) Management and Storage Methods of Spare Parts

- Improvement of inventory management process (arrangement, outdoor storage)

7) Organization of the Power Plant

- Improvement of management od performance test data and operation date (speed-up)
- Clarify the personnel who manages the data of secular distortion etc.

8) Procurement Method of Parts/Materials for Maintenance or Overhaul

- Simplification and speed-up of purchasing procedures
- Risk of competitive bid for parts of major equipment

9) System for Authority and Responsibility

- Authority and responsibility for overhaul schedule (keeping schedule)
- MMRC and plant manager should be authorized to purchase everything necessary for routine work.

10) Contracting Methods for Overhaul and Preventive Maintenance

- Repair work by the original manufacturer or hiring supervisor

11) Management at Head Office and MMRC

- Review of organization and capacity of MSD
- Shortage of manpower and technician of MSD, casual workers and contractor

12) Hiring and Education/Training of Employees

- Hiring Guideline: No regular hiring
- Lack of collective training, job rotation and position rotation
- Position training of operators should be regularly conducted.
- Training by the operation simulator is required.
- Improvement of ethics