CHAPTER 5

IMPROVEMENT PLAN OF POWER PLANT OPERATION AND MAINTENANCE MANAGEMENT (SOFTWARE)

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5.1 Present Conditions and Problems

5.1.1 Operation Management

1) Operation Manuals

a. Need for Operation Manuals

The basics of operation management of a power plant is to control target values and keeping performance, and prevention of accidents. It is imperative to have experienced operators conducting operations with constant attention to prevent accidents. For this, it is essential that manuals be prepared covering Unit Start-up/Shutdown Procedures, Special Operations, Individual Equipment Operations, and Troubleshooting.

b. Availability of Appropriate Operation Manuals

a) Unit Start-up/Shutdown Procedures

The Standard Operating Procedure (SOP) manuals have already been completed for NPC's hydraulic, thermal, geothermal and diesel power plants and substations. For thermal power plants, separate procedures have been prepared for once-through boiler units and conventional (drum) boiler units, each outlining the start-up/shutdown procedures in the form of a flowchart.

b) Special Operations

The Sliding Pressure Operation Procedure for the Malaya Unit No. 1 is the only completed manual. No other special operation manuals have been prepared.

c) Individual Equipment Operations

The instruction manuals provided by the manufactures are used as the operation manuals for equipment. There are no individual equipment operation manuals prepared by the NPC in which the characteristics of the related equipment and system of the plant are considered.

Flow Diagrams, Logic Diagrams, Interlock Diagrams, etc. are taken directly from the drawings provided by the manufacturers.

Most of these instruction manuals provide general information rather than information peculiar to the plant.

d) Troubleshooting Manual

The manuals for Emergency Systems - Standard Operating Procedures have already been completed for the NPC's hydraulic, thermal, geothermal and diesel power plants and substations, in which outlines of major troubleshooting procedures are described. There have been no troubleshooting procedure manuals prepared by the NPC for individual equipment in the Malaya TPP. The manufacturers' instruction manuals are used, as they already include troubleshooting procedures for individual equipment.

e) Unit Start-up/Shutdown Curve

The unit start-up/shutdown curve for cold start has only been prepared. The curve for warm start or hot start has not been prepared. However, using the cold-start curve, the operations superintendent determines factors such as pressure-up/temperature-rise ratio, rolling time, speedup ratio and load change ratio by referring to flowcharts in the manufacturers' instruction manuals, and gives the appropriate instructions to the operators. The listing of required times for each start-up/shutdown pattern has not been prepared.

f) Long-term Shutdown Unit Preservation Manual

Pursuant to "Equipment Preservation Methods" prepared by MMRC, preservation methods are specified according to the shutdown period for the boiler, deaerator, feedwater heater, condenser, turbine, generator, motor, and other equipment.

2) Daily Patrol and Inspections, and Routine Work

a. Purpose of Daily Patrol and Inspections, and Routine Work

In order to prevent accidents or troubles with equipment during operation, the equipment should be monitored/checked for abnormalities in operating conditions as well as for pressure, temperature, vibration or noise. If any abnormality is found, proper measures should be promptly taken. For this, daily patrol and inspections of equipment are necessary. At power plants in Japan, a cross-check system is employed where, ordinarily, operators and maintenance staff respectively conduct patrol and inspection from the perspective of their own specialties to ensure perfection. They use a patrol check sheet to prevent careless or aimless patrol. Additionally, daily maintenance (such as equipment lubrication or the cleaning of heavy oil burner tips) and routine work (such as periodic changeover tests of spare equipment) are controlled through use of a monthly routine list, routine check sheet, etc.

b. Practice of Daily Patrol and Inspections, and Routine Work

a) Daily Patrol and Inspections by Operators

An Hourly Shift Patrol Checklist is prepared for each of the 15 operator positions (M1/M2-switchboard, M1/M2-boiler x 2, M1/M2-turbine x 2, M1/M2-basement, screen, booster pumps, master electrician), and hourly patrol and inspections are carried out. The Turnover Checklist has to be filled out once per shift by both the Operations Superintendent and Operations Principal Engineer.

At the Malaya TPP, there have been some complaints that there are too many field patrol items of excessive frequency, putting a burden on daily operations. However, the NPC Head Office and MMRC believe that patrol and inspections of this extent should be carried out.

No daily patrol and inspections are conducted by the maintenance staff.

b) Stand-by Equipment Change-Over Tests and Other Periodic Routine Operations

- As a general rule for equipment comprising 2 units, both having 100% capacity, e.g. fuel oil pumps, one unit is reserved as a standby unit, while the other is used for operation. The main fuel oil pump is changed over to the standby unit once a month. A weekly changeover is conducted for the condensate pump, raw water pump, house service cooling water pump, air compressor, etc.

- As a routine procedure for the turbine, a weekly test of the turbine protective device and a daily open/close test for the main valve are carried out.

- While routine tests and operations for other auxiliaries are controlled in accordance with the Preventive Maintenance Work Order (PMWO), no monthly routine lists or routine operation check sheets have been prepared.

c) Lubrication and Cleaning of Equipment

During operation, the equipment is lubricated and cleaned by the operators, in accordance with the standards of the PMWO, and a comprehensive lubrication management table has been prepared.

d) Management of Heavy Oil Burner Tips

Disassembled check and cleaning of the burner tips are carried out at the Malaya TPP every week. The burner tips are checked with three types of gauges. Defective tips are replaced with new one.

3) Operational Rotation System

a. Operation Staff

The Malaya TPP is a heavy oil-fired thermal power plant, which has 2 units, rated 300 MW and 350 MW each, for a total output of 650 MW. Under a central control system, the two units are monitored and operated from the same central control room. In 1989, within the premises of the power plant, a 90 MW (30 MW x 3 units) gas turbine power plant was additionally constructed. Its control room is situated beside

the gas turbine unit.

The 230 kV substation (NPC facility) and 115 kV substation (MERALCO facility) each have an exclusive control room.

The operators at the gas turbine power plant and 230 kV substation belong to the Malaya TPP.

The number of operation staffs (complement) is as follows:

Office of Operations Manager	2
Shift Operations (Power Plant)	105
Chemical Service	22
Gas Turbine/Substation Operations	23
Fuel	9
Total	161 persons

The complement of the operations staff and the actual occupancy of each position are as listed in the following clauses, Shift Staff Structure.

b. Shift Staff Structure

The shift structure for the power plant shift operations and gas turbine/substation shift operations are as shown in Tables 5-1 and 5-2.

Table 5-1 Shift Staff Structure for Power Plant Shift Operations

Position	Shift Duty Staff	Occupancy/Complement
Operations Superintendent A	1	5/5
Operations Principal Engineer B	2	10/10
Boiler		
Sr. Control Operator B	2	10/10
Plant Equipment Operator B	2	10/10
Plant Equipment Operator C	2	9/10
Turbine		
Sr. Control Operator B	2	9/10
Plant Equipment Operator B	2	10/10
Electrical Control (Switchboard)		
Sr. Control Operator B	1	5/5
Electrical Control Operator B	1	5/5
Sr. Plant Electrician	1	5/5
Auxiliaries		
Basement Operator B	2	10/10
Screen House Operator	1	4/5
Booster Pump Operator	1	5/5
Wharf Operator	0	0/5
(dual duty with Booster Pump)		(97/105)
Chemical Service		
Principal Chemical Engineer C	1	4/5
Plant Equipment Operator B	2	11/15
		(15/20)
Total	23	112/125

Note) - "Shift Duty Staff" refers to the required number of staff for the operation of the 2 Units. When only one unit is in operation, as during the periodic maintenance, the stand-by staff conduct the daily patrol and inspection, and daily maintenance work.

- Acceptance of fuel oil transported by barge from Sucat, was previously done by NPC. Currently the PPC (Philippine Petroleum Company) receives and supplies it to NPC, making the Fuel Group staff redundant. The booster pump operator handles the acceptance into the fuel oil tank from the PPC.

- The chemical service staff is in charge of sampling, analysis of water quality, operations of water treatment equipment and daily maintenance work of chemical facilities.

Table 5-2 Shift Staff Structure for Gas Turbine/Substation Shift Operations

Position	Shift Duty Staff	Occupancy/Complement
Gas Turbine		
Principal Engineer B*	1	4/4
Sr. Control Operator B	1	4/4
Plant Equipment Operator B	1	3/4
Sr. Plant Electrician	1	2/3
Substation		
Principal Engineer B* (dual duty with G/T)	(1)	
Sr. Control Operator B	1	3/4
Electrician, Control Operator B	1	2/4
Total	6	18/23

c. Shift Categories

Each shift is 8 hours. Due to peace and order conditions in the area of the Malaya TPP, midnight shuttle bus operations have been suspended since 1989, requiring the No.3 Shift and No.1 Shift run consecutive duty.

No.1 Shift	(Night Shift)	11:00 p.m. - 7:00 a.m.
No.2 Shift	(Day Shift)	7:00 a.m. - 3:00 p.m.
No.3 Shift	(Afternoon Shift)	3:00 p.m. - 11:00 p.m.

During a shift, no breaks are given which means an 8-hour restriction and work duty. The work hours slightly fluctuate depending on the shuttle bus arrival time. The staff eat inside the control room.

d. Shift Schedule

An example of a shift schedule of October 1994 is shown in the Table 5-3.

Table 5-3 Shift Schedule (October 1994)

Mon.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Day	S	Su	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su	M
A	x	3	1	2	3	1	x	x	3	1	3	1	2	x	x	2	3	1	3	1	x	x	3	1	2	3	1	x	x	3	1
B	2	2	3	1	x	x	2	3	1	3	1	x	x	3	1	3	1	2	x	x	2	2	2	3	1	x	x	2	3	1	3
C	3	1	x	x	2	3	1	2	2	x	x	3	1	2	3	1	x	x	2	3	1	3	1	x	x	2	3	1	2	2	x
D	1	x	x	3	1	2	3	1	x	x	2	2	3	1	2	x	x	3	1	2	3	1	x	x	3	1	2	3	1	x	x
E	x	x	2	O	O	O	O	x	x	2	O	O	O	O	x	x	2	O	O	O	O	x	x	2	O	O	O	O	x	x	2

Note) 1 - Night Shift (11 p.m. ~ 7 a.m.) 2 - Day Shift (7 a.m. ~ 3 p.m.)
3 - Afternoon Shift (3 p.m. ~ 11 p.m.)
O - Day Time (7:30 a.m. ~ 4:30 p.m.) X - Day off

- The system is 5-group, 3-shift. One of the group has a Day time duty every 5 months, where the days-off are Saturdays and Sundays, and Day shift comes on Mondays.
- The other 4 groups have 5 consecutive work days and 2 days off. Because of the unsafe situation in the area at night, the Afternoon and Night Shifts are consecutive.
- The combination of Operations Superintendent and the operator(s) is fixed for the Day Time duty month. However, it will be combined with another shift group for the shift duty months.

c. Residential Status and Commuting Methods of Malaya TPP Employees

a) Roughly 96% of the Malaya TPP employees reside in the Metro Manila district and roughly 4% reside in a rural area. Approx. 70% own their own houses and approx. 30% rent their residence.

Although the Malaya TPP does not have company housing, about 30 employees live in the company housing provided by the NPC Head Office in Quezon City.

b) Commuting Methods

95% use a shuttle bus service provided by the NPC, while the other 5% drive or walk. A majority of the employees use the shuttle bus from Metro Manila or the coastal towns of Laguna Lake. The total time required for commuting is one and a half or two hours on the bus, plus the time needed to get from the employee's residence to the bus stop.

c) Shuttle Bus Operation Schedule

Figure 5-1 Shuttle Bus Operation Schedule

	Metro. Manila		Malaya Power Plant				Metro. Manila
	Leave		Arrive		Leave		Arrive
		O/M				O	
No.1 bus	5:50 a.m.	→	7:30 a.m.	→	8:00 a.m.	→	9:30 a.m.
		O				O	
	1:30 p.m.	→	3:00 p.m.	→	3:45 p.m.	→	5:00 p.m.
		O/M				M	
No.2 bus	5:50 a.m.	→	7:30 a.m.	→	4:30 p.m.	→	6:00 p.m.

Note) O: Operation Group use
M: Maintenance Group use
Shuttle bus: two large-size buses rental, passenger capacity 65 persons per bus

d) Shuttle Bus Route

The routes for two shuttle buses are as follows:

No.1 bus

(direct)

Quezon → Malaya TPP → EDSA → Malaya TPP → EDSA → Quezon (garage)

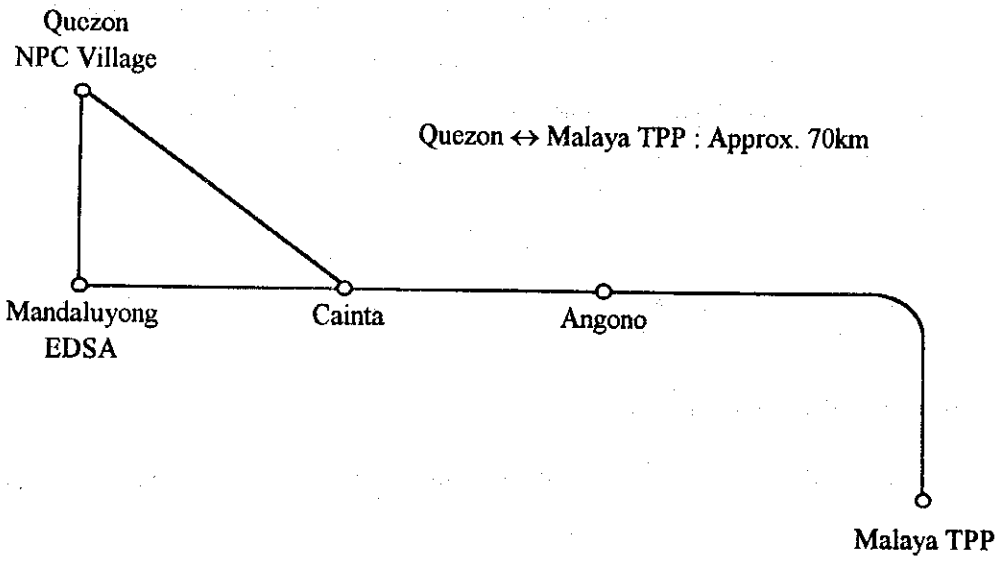
No.2 bus

Quezon → EDSA → Malaya TPP → EDSA → Quezon (garage)

Quezon: Tandan Sora NPC Village

EDSA: Mandaluyong, EDSA(Epifanio De Los Santos Ave.)-SHAW Crossing

Fig. 5-2 Shuttle Bus Route



5.1.2 Maintenance Management

1) Maintenance Procedure

a. Current Status of Managed Maintenance Program (MMP)

NPC started an ad hoc project in charge of MMP development in July 1990 with the objective to improve power plant availability and reliability.

The MMP for the majority of plants were already developed as of September 1994 as shown in Table 5-4.

Regarding thermal power plants, MMP have already entered the stage of practical implementation at all of the existing plants.

Table 5-4 Development Status of MMP

Type of Plant	No. of Plant	Present Status
Thermal Power Plant	6*1	Completed (Refer to Table 5-5.)
Geothermal Power Plant	4	
Diesel Power Plant	5	
Hydro Power Plant	10	
Substation*2 and Power Barge	6 each	Under development as of 1994

Note: *1 Bataan TPP, Manila TPP, Malaya TPP, Sucat TPP, Batangas Coal-Fired TPP, Naga TPP

*2 Additional through Job Order

b. Present Status of Operation of MMP at Malaya TPP

The MMP is composed of the three programs indicated below.

- Preventive maintenance (PM) program
- Corrective maintenance (CM) program
- Spare part management (SM) program

Table 5-5

MMP RECIPIENT FACILITIES

1. Magat HEP
2. Binga HEP
3. Pantabangan/Masiway HEP Complex
4. Angat HEP
5. Bataan Thermal Power Plant Complex
6. Manila Thermal Power Plant
7. Malaya Thermal Power Plant Complex
8. Sucat Thermal Power Plant (Unit 1 & 4 only)
9. Kalayaan/Botocan/Caliraya HEP Complex
10. Mak-Ban Geothermal Power Plant Complex
11. Batangas Coal-Fired Thermal Power Plant
12. Tiwi Geothermal Power Plant Complex
13. Panay Diesel Power Plant I
14. Leyte Geothermal Power Plant
15. Naga Thermal Power Plant
16. Cebu Diesel Power Plant II
17. Bohol Diesel/Loboc HEP
18. Palinpinon Geothermal Power Plant
19. Aplaya Diesel Power Plant
20. Agus 1 & 2 HEP Complex
21. Agus 4 & 5 HEP Complex
22. Agus 6 & 7 HEP Complex
23. Pulangi 4 HEP
24. General Santos Diesel Power Plant
25. Power Barge 101
26. Power Barge 103

* 27 Banilad Substation

Note: * Additional thru Job Order

At the Malaya TPP, the programs except the one for Spare Part Management are used in practice, and the procedure has been completed by around 50%. See Appendix 5-1.

c. Maintenance Procedure

The duties of the MMP development project included another important duty besides development of the programs stated above. It is compilation of maintenance procedures. Besides the procedures for the activities implemented by PM (Preventive Maintenance) or CM (Corrective Maintenance) orders of MMP, administrative procedures were also created from the standpoint of maintenance management.

a) The composition of the maintenance procedures created by this time is as follows.

Administrative Procedures

ADP: Administrative Procedures

Technical Procedures

MMP: Mechanical Maintenance Procedures
EMP: Electrical Maintenance Procedures
ICP: Instrument and Control Procedures
RTP: Results Testing Procedures
CAP: Chemical Analysis Procedures
TDC: Technical Document Control Procedures

b) At the Malaya TPP, the following procedures are already completed.

ADP: 21 items
MMP: 9 items
EMP: 14 items
ICP: 8 items
RTP: 8 items
CAP: 29 items
TDC: 7 items

c) Malaya TPP Maintenance Procedures

The approach in the examination of already created maintenance procedures was as follows.

Comparison of the items of the procedures of NPC in each classification with cases of Japan.

A list of MMP procedures of Malaya TPP is shown in Appendix 5-1.

Contents of procedures themselves are not studied in this report. (They were arranged at the MMP project by spending a long time and the volume is large.)

The result of the study are as described in the following.

Administrative procedures

- Procedures related to laws

  In Japan, many of the administrative procedures related to power plants are provided by laws, and they include technical standards and inspection procedures for power generating facilities.

  Principal ones of these administrative procedures are indicated below.

  - Electricity Enterprises Law
    - Technical standards for power generating facilities
    - Technical standards related to welding
    - Safety regulations (contents of safety operations, organization for safety management, setup of chief engineers, etc.)
    - Periodic inspection
  - Labour Safety and Hygiene Law
    - Crane safety regulations
    - Prevention of oxygen deficiency
    - Measurement of working environment
    - Others
  - Fire Services Law
    - Technical standards related to fire fighting equipment
    - Regulations related to control of dangerous materials
  - High Pressure Gas Control Law
  - Building Standard Law
  - Air Pollution Preventive Laws, Water Pollution Preventive Laws and Noise Restriction Laws

It seems necessary for NPC to make administrative procedures regarding such items mentioned above. Among 21 items which have been provided by this time, nothing is equivalent to such administrative procedures.

Followings are considered to be missing or added compared to maintenance manual and technical administrative manuals for power plants in Japan.

- Budget conduct procedure
- Work proceedings procedure
- Management and guidance of contractors
- Inspection procedure

The inspection program has been made at Malaya TPP, however, it seems recommendable to take reference from the one made in Japan as a hint of the method for rearrangement of inspection planning such as "planned maintenance management chart" and "inspection schedule for the month."

See Appendix 5-2 and Appendix 5-3.

- Maintenance conduct procedures
  - Calling of maintenance personnel
  - Witnessing
  - Management of equipment internal work
  - Management of vibration of turbine generators and major rotary machines
  - Operation of overhead traveling cranes
  - Marking of buried substances
  - Management of in-furnace working environment
  - Management of annual deterioration of major equipment
- Countermeasures for disaster prevention
- Management related to environment

<u>Technical procedures</u>

- The majority of procedures of the MMP are the disassemble inspection procedures and test procedures.
- Various performance test procedures for RTP of NPC are well completed.

- In the case of Japan, disassembly and reassembly of machines are implemented by professional subcontractors in almost all cases, and accordingly, the disassembly and reassembly procedures are mainly managed by subcontractors. Maintenance Services Dept. (MSD) of NPC has the same kind of procedures, but of summary on major equipment.
- Periodic Inspection Standards

  In Japan, it is stipulated by law that boilers and turbines be subjected to inspections (periodic), by order of the Ministry of International Trade and Industry. In accordance with this law, the authorities concerned issue a notice regarding the implementation of periodic inspections. This notice includes implementation procedures indicating the time and contents of periodic inspections for boilers and turbines. Appendix 5-4 contains the implementation procedures. Power and other companies base their periodic inspection and maintenance standards on these implementation procedures. In addition to boilers and turbines, they have formed their own standards for other sections, such as electric and control sections. In the Philippines, as there are no laws or regulations covering periodic inspections, no standards for periodic inspections and maintenance are made by the NPC.

2) Daily Maintenance

a. Preventive Maintenance (PM) and Corrective Maintenance (CM)

A document prepared for presentation of the MMP contains the following definition.

"PM is defined as routine recurring work required to keep equipment and components in such a condition that they can be used at original or designed capacity or efficiency."

"CM is the restoration of an equipment and components to a condition equal to original or designed capacity and efficiency by replacing parts or materials after they have deteriorated."

PM and CM are combined and called daily maintenance in Japan. Table 5-6 indicates a comparison between PM and CM under the definition of MMP. The objective of each of PM and CM is upkeep of performance or efficiency of equipment and

components. But it can be said that PM lays emphasis on early discovery of abnormality and CM lays emphasis on repair or replacement of faulty points.

Table 5-6 Comparison between Preventive Maintenance and Corrective Maintenance

Item	PM	CM
- Responsible Division or Group	- Thermal Power Plant, Maintenance Group	- Thermal Power Plant Maintenance Group - MMRC Maintenance Service Department (MSD)
(Contents of Implementation) - Applicable facilities - Interval of implementation - Work order - Items and method for implementation	- Whole plant - Daily, weekly or monthly - By PM work order - Check for abnormality of equipment is made for specified items by specified methods using provided or test instruments.	- Whole plant - When required - By CM work order - Overhaul, that is, inspection and servicing, is made. - Secular deteriorated parts and materials are replaced.
- Effect	- Early discovery of abnormality - Planned repair can be made accordingly - Major repair caused by unexpected failures is reduced. The maintenance cost is reduced as a result.	- Check of points requiring repair and their current conditions can be learned. - Planned repair can be made accordingly. - Reliability and efficiency of facilities are recovered. - Same as left.
- Aim of MMP	- To systematically implement the contents stated above based on a computer program. - To reflect accumulated inspection data to the next inspection and maintenance planning. - Others	- To establish a system to identify, inspect and determine points requiring repair as well as remedy. - To make a status report including points requiring repair, equipment and materials for needed the subject repair, remaining work, maintenance statistics, etc. - Others
- MMP capability (from MMP Development Plan)	- Company policy and implementation plan will be incorporated. - Formation of operation plan - Work Order system shall be rationalized and simplified, and processed by computer. - Report preparation - Continuous recording of maintenance history	- Same as on the left - Simplified preparation of power plant faulty section report - Same as on the left - Report preparation - Maintenance and accumulation of facility maintenance and repair records

b. Implementing status of PM Program at Malaya TPP

a) PM Program Procedure

The procedure is specified in registration No. MYTP/ADP-04 dated January 24, 1992.

b) PM work schedules

- The PM work schedules are classified into the following two types.
  - Weekly PM schedule (See Appendix 5-5)
  - Monthly PM schedule (See Appendix 5-6)

- Each schedule (list) prints out PM work order No., inspection items (PM activity description), inspection date (scheduled data), etc. for each equipment to be inspected.

- The schedule is issued by Planning and Scheduling (P & S) Section of the Maintenance Group. (Output with the computer.) The schedule (list) is provided for each section of the Maintenance Group. These schedules are reviewed by P & S Section in the Maintenance Group, and are approved by the Maintenance Group manager before implementation.

c) PM work order and its system

- A typical implementation of work order is shown in Appendix 5-7. Each work order is issued by P & S Section for each equipment indicated in the PM schedule. Results of inspection (work summary/remarks) are entered in the work order besides inspection items (planned activity sequence).

- The work order flow is shown in Appendix 5-8.

c. MMP at Malaya TPP

The approach in the examination of the MMP was as follows.

- Comparison of equipment registered in the PM schedule as well as inspection items and frequency with cases of Japan provided, however, that the degree of completion at Malaya TPP was told as being around 20%.
- No database was available regarding CM work orders.

The results of study of PM schedule are as follows.

a) Boilers

- PMWO's are provided for large size fans such as FDF and GRF and for fuel oil pumps.
- The operations for inspection of the following equipment are to be involved in addition to the above;
  Inspection of boiler main unit, inspection of burners and their surroundings, cleaning of burner tips, inspection of damper drive units, inspection of valves of the fuel system and inspection of tanks.
- The inspection frequency is about the same between Malaya TPP and Japan, and weekly inspection and monthly inspection are conducted.

b) Turbines

- PMWO's are provided for the following equipment;
  Major pumps such as feed water pumps, condensate pumps and cooling water circulation pumps. Turbine gland steam, house service cooling water pumps, screen washing pumps, turbine drain pumps.
- The operations for inspection of the following equipment are to be involved in addition to the above;
  Turbine main unit, lubricating oil system, major valves, etc. (See Appendix 5-2.)

c) Electrical

- PMWO's are provided for batteries and stator cooling water pumps only.
- The operations for inspection of the following equipment are to be involved in addition to the above;
  Inspection of generators, transformers, and high/low voltage motors, measurement of insulation of principal equipment, etc. (See Appendix 5-2.)

d) Instrumentation and Control

- Servicing of recorders is the main item, and inspection of flame detectors is the only one item besides servicing of recorders.
- Inspection and servicing of the following important equipment are remaining; ABC equipment, burner management system, local controllers, turbine supervisory instruments, local control panels, etc.

d. Implementing Status of CM Program at Malaya TPP

a) CM Program Procedure

The procedure is specified in registration No. ADP-05, Revision No. 2 dated January 30, 1992.

b) CM work order and its system

Appendix 5-9 indicates a typical CM work order.

Each issued work order is processed from the top of this page toward the bottom in the flow indicated below. Appendix 5-10 indicates its flow chart.

Work order flow

Originator:	Any individual who identifies a problem or activity which requires him to prepare for CM work order (CMWO).
↓	
Operations:	The shift manager puts the priority of the processing depending on the situations of the trouble. He enters necessary instructions and date in the work order and forwards it to P & S Section of Maintenance Group.
↓	
P & S Section	Enters the contents (activity) of repair work, required persons, required time, materials, scheduled date of completion of work, etc. in the format, and forwards the format after the approval of the superior officer to the Operations.
↓	
Operations	When the shift manager judges that it is OK after checking of the repair plan, he enters the date and approval signature in the work order, and forwards it to the Maintenance Group.
↓	
Maintenance Group (Work Center):	Repair is implemented. The results of repair are entered. After entry of date and signature of the person responsible for implementation, the document is forwarded to the Operations.
↓	
Operations	The operator who witnessed the work and the shift manager confirm the completion of work and result of work.
↓	
P & S Section	The document is finally reviewed by the chief of the P & S Section and the flow is completed.

This system is basically the same as the maintenance request slip system used in Japan.

c) Work Controlled by MSD

In case of emergency, what can be handled at the power plant is repaired based on a CMWO stated earlier. But if the item cannot be handled at the power plant, urgent request is made to MSD by telephone. (Operations manager → MSD manager) If no urgency is required, repair is requested to MSD with an order sheet delivered to MSD.

e. Yearly Maintenance Cost Planning

The budget for the next fiscal year is applied to MMRC in May-June period of every year, and the amount of the budget is determined in December. The contents of application include APEX (personnel expenses), OFEX (fuel expenses), and CAPEX (repair expenses, spare parts). CAPEX is cut by around 5% every year.

3) Periodic Overhaul and Preventive Maintenance Plan

a. Current Condition of Periodic Overhaul

Although the NPC's thermal power plants should be subject to annual periodic overhaul inspections (hereinafter referred to as 'periodic inspections'), they were not always carried out as planned. This was because of repeated postponements of periodic overhaul due to an aggravated power supply, a situation which may recur because there are no regulations as in Japan. Also, there are no standardized inspection items for periodic inspections. In order to carry out long-term management of equipment, it is imperative to monitor the changes accompanied by long operation or frequent start-up/shut-down. Thus, standards and know-how should be prepared to implement a thorough periodic overhaul plan, to include the establishment of standards for checkpoints. The NPC's current periodic inspection plan is implemented as follows.

b. Offices in Charge of Periodic Inspection Planning

a) Each plant makes the plan on work contents, duration and time, etc. for coming periodic overhaul before submitting to MMRC.

b) Operations Projects Services of MMRC is in charge of carrying these plans into summarized schedule that will be agreed by all plants and MSD under MMRC.

c) System Operation Department of Head Office authorizes the Annual overhaul schedule when the time and period of periodic inspection is decided for each plant.

Besides, for five years to come, each plant usually makes the overhaul plan.

c. Main Contents of Inspection of Major Equipment

a) Inspection of boiler water wall tubes (burner zone) by way of sample tube is implemented every year. Chemical cleaning is planned with scale attachment on the inside tube surface of 37 mg/cm^2 as the limit.

b) There is no periodic standard for sample tube inspection of SH, RH and economizer tubes. Sample tubes shall be taken from such a section where any abnormality is recognized.

c) Measurement of tube thickness of burner zone water wall tubes is implemented every year and the time of replacement of water wall tubes is estimated.

d) Dismantled inspection of turbines is made once every three years. Inspection of rotor as taken out is implemented once every five years, and non-destructive inspections such as MT, UT and PT are implemented at such occasions.

e) Inspection of insulation of generators is implemented every year.

f) Disassembled inspections of essential pumps are implemented once every three years.

d. Preparation for Overhaul

a) Internal meeting of the power plant and joint meeting between power plant and MSD are started three months prior to the implementation of overhaul, and division and allotment of work to the power plant and MSD are adjusted.

b) Coordinate meeting is held one month prior to the overhaul, and confirmation of contents of work, schedule and division and allotment of work to the power plant and MSD are made.

The members of this coordinate meeting are Maintenance Group of the power plant, MSD, MEC, MMRC's Operation Projects Services and Efficiency Reliability Department of NPC Head Office.

c) The contents of work are determined from the following factors.

- Annual inspection plan schedule of major equipment
- Information from Operations groups such as CMWO
- Examination of problems encountered during operation and examination of operation data
- Comprehensive Patrol for Inspection Before Overhaul
  A task force is organized by the Operations Group and Maintenance Group about one month before the start of overhaul, and comprehensive patrol for inspection is implemented.
- Dissemination of Information on Similar Troubles
  Trouble information from other power plants are disseminated through MMRC. Major troubles are disseminated from NPC Head Office. The information that is necessary for overhaul is used as a reference.

e. Preparation of Equipment and Materials for Overhaul

a) All of the articles required for overhaul are procured by the power plant including those for the work under the control of MSD.

b) The expenses for tools, machines, materials, wages, etc. used by MSD are born by MSD.

c) In the case of purchase of imported articles, arrangement is made with a procurement lead time of two to three years for large articles, and one year for small articles. Procurement lead time of six months is required for domestic products.

d) For purchase of articles which are beyond the authority of the power plant manager (10,000 pesoes), application is made from the power plant manager to the MMRC vice president.

f. Preventive Maintenance Plan

The activities covered by preventive maintenance are interpreted as management of aged deterioration and diagnosis of remaining service life. But, in case of NPC, daily maintenance, weekly maintenance, monthly maintenance, lubrication schedule and cases where signs of troubles are observed and repair is made during the weekend shutdowns are included in the preventive maintenance.

Records of secular deterioration inspection at Malaya TPP in the past are: implementation (implemented by MEC) of hardness measurement and UT of No. 1 boiler tubes in 1992, implementation of aged deterioration inspection of No. 2 turbine, UT of high temperature bolts and replacement of deficient parts in 1993-4.

It seems that inspection for aged deterioration is understood by NPC to be implemented by the manufacturer during rehabilitation. Records of aged deterioration inspection of only two cases mentioned above are kept in the overhaul record.

g. Management of Maintenance Record

Records of equipment troubles, repair, modification, etc. are kept as overhaul records. But such as ledger of history of equipment maintenance for each equipment is not available. Such recording was adopted since 1992 for major rotary equipment. Such records are also produced in Japan besides overhaul records. (The contents of description of them are naturally overlapped.)

4) Overhaul Procedure and Implementation Structure

a. Division of Duties at the Time of Overhaul

In general, the division of duties to MSD and power plant's maintenance group at the time of overhaul is as follows;

MSD:	Major equipment such as main turbine, generator, excitor, boiler's high pressure portions, air heater, condenser (tube washing), gas ducts and auxiliary boiler.
Power Plant's Maintenance Group:	Other auxiliaries such as pumps, fans, soot blower and valves.

But the division of actual works is adjusted before start of the overhaul based on the manpower of both parties and workload.

b. Safety Management of Overhaul

Regulations on use of work tags are included in the MMP, and attachment of danger warning tags to the power supply and control switches, attachment of tags to isolate valves, tags for welding work, etc. are specified. Management of permit on the use of open flames and permit on high temperature works is also specified. No MMP has no provisions regarding management of works performed inside of equipment, but actual management is being made. It is considered that all of these will be rearranged in the MMP in the future. But since there are important and critical items of quality control such as prevention of disasters caused by human errors such as oxygen deficiency, bring-in of earth and sand to equipment interior, falling of tools and leave-out of tools, it is desirable that regulations are set up as early as possible.

c. Disassemble Inspection Manuals for Major Equipment

Equipment disassemble inspection manuals of about ten items were prepared in the MMP. It is considered that addition will be made sequentially in the future. As major equipment such as main turbines, high pressure portions of boilers and feed water pumps are under the control of MSD, they are not included in the MMP of the power plant. MSD is preparing disassemble inspection manuals for the following equipments;

- Generator
- Turbine manufactured by Siemens
- Circulating Water Pump
- Boiler Feedwater Pump
- Secondary Super Heater
- Boiler Safety Valve

These manuals are rough compared to those in Japan, and nothings about safety management or quality control are found in them.

Other equipments seem to have no disassemble inspection manual, and are inspected based on experience of inspectors.

d. Contents of Inspection and Servicing of Equipment and Scope of Works

Standardization of maintenance works has not yet been made at NPC. It is considered that inspection schedule of NPC are based on the know-how obtained by experience of each section or supervisor. For internal inspection of a drum, for instance, it is necessary to remove all the internal obstacles for the ease of inspection of weld lines at the bottom. At NPC, for the moment inspection of visible range is made without removing internal obstacles.

e. Present Status and Future Plan of Overhaul Interval

The overhaul schedule of each power plant is finally determined by the System Operation Department of NPC Head Office. It was initially scheduled that annual overhaul be implemented every year at each thermal power plant of NPC. But due to critical power supply situation, overhaul could not be conducted as planned as stated earlier. Overhaul of Malaya unit No. 1 was implemented only four times in the past eight years, and for Malaya unit No. 2 only three times in the past nine years. However, it is planned that annual overhaul will be implemented every year in the future.

f. Overhaul Records

Overhaul records are prepared by compilation of those of manufacturers. Overhaul records are also prepared by power plant taking reference from that of manufactures these days.

g. Organization and Structure for Overhaul Work

The organization and a document describing the responsibility of each party for the overhaul of this time of Malaya TPP were acquired at the power plant. See Figure 5-3 and Table 5-7. A functional structure specific to overhaul was produced.

a) The top of the responsible person is the power plant manager.

b) A project coordinator and an assistant project coordinator are assigned under the plant manager for coordination and supervision of the whole overhaul. Either one of the managers of the Operations Group or the Maintenance Group is appointed as the project coordinator. The project coordinator coordinates the total processes of overhaul and substantially conducts total supervision.

c) MSD's electrical and mechanical engineers join the working group besides the Maintenance Group of the power plant.

d) The following four groups are assigned as staff members under the project coordinator.

- Operation Tagging & Isolate Group
  This group is organized during the overhaul only with staff selected out of mechanical, electrical and instrumentation groups. This groups executes isolation, safety tagging, final judgment of result of trial operation, etc.
- Planning & Scheduling Group
  This group conducts schedule control.
- Safety Engineer for Safety Management
- Materials & Supplies for Supply of Equipment and Materials

e) Total supervision of comprehensive trial operation is conducted by the project coordinator. Substantially, however, the Operation tagging & isolate group carries out total supervision.

h. Actual Condition of Overhaul Work

The organization stated above is considered to be satisfactory and functional. In practice, however, arrival of MSD group at the power plant delayed and actual start of overhaul was postponed. It was explained that overlap of the overhaul schedules with other power plants caused shortage of manpower of MSD and the delay in manning to Malaya TPP. Such a matter is one of the most important factors in the management of the whole NPC, and countermeasures for solving the problems should be established with a meeting attended by relevant staff of Malaya TPP, MSD, MMRC, System Operation Department, etc. prior to start of overhaul. In addition, we

were told that time spent to search for equipment disassembly tools was one cause of the delays. This may be because MSD did not have enough time for preparation. Equipment, tools and work vehicles are terribly insufficient.

According to MSD, one major overhaul plus one minor overhaul is their limit of the manpower capacity.

- Major overhaul means a work of around 100 days.
- Minor overhaul means a work level of opening up turbine upper half with blade and bearing inspection.

i. Problems in Subcontracting

MSD supplements manpower by subcontracting or temporary hiring. However, except for some welders and semiskilled workers, most of the employees are only helpers, of doubtful value as active workers.

In Japan, periodic overhaul general contractors use subcontractors, and each individual subcontractor is itself and expert company which can be counted as a powerful contributor. Accommodations are nonexistent for MSD and for subcontractors. Most suffer a long commute and cannot work overtime. Thus, the workers' motivation to work is affected. In Japan, dormitories are complete for those who assist in periodic overhauls. The general contractor handles all lodging for subcontractors, or hires local subcontractors who do not require lodging arrangements.

j. Hints on Overhaul

When the unit is shutdown for overhaul, inspection of major equipment such as boilers and turbines should be conducted as quick as possible. Efforts should be exerted to enable quick inspection to identify problems and to complete repair work within remaining overhaul period.

In the case of Japan, since the manufacturers of boiler, turbine, etc., have their own factories within the country full cooperation of them can be expected for the supply of the parts, materials and dispatch of supervisors when emergency needs are encountered during the overhaul and most of the overhaul work can be finished within the schedule or with minor extension.

In such a case, however, since it is not possible to catch up with the schedule if work contract is made by regular proceedings, the work is performed in an urgent manner on the basis of provisional agreement subject to the later price negotiation with these concerned manufacturers.

Since the circumstances of NPC are different, it may not be possible to use the same system. However, once a unit is shutdown, major equipment should be inspected soonest to discover problems and the remaining overhaul period should be effectively used.

Figure 5-3 Malaya 1 Overhaul Table of Organization (September 1 to December 10, 1994)

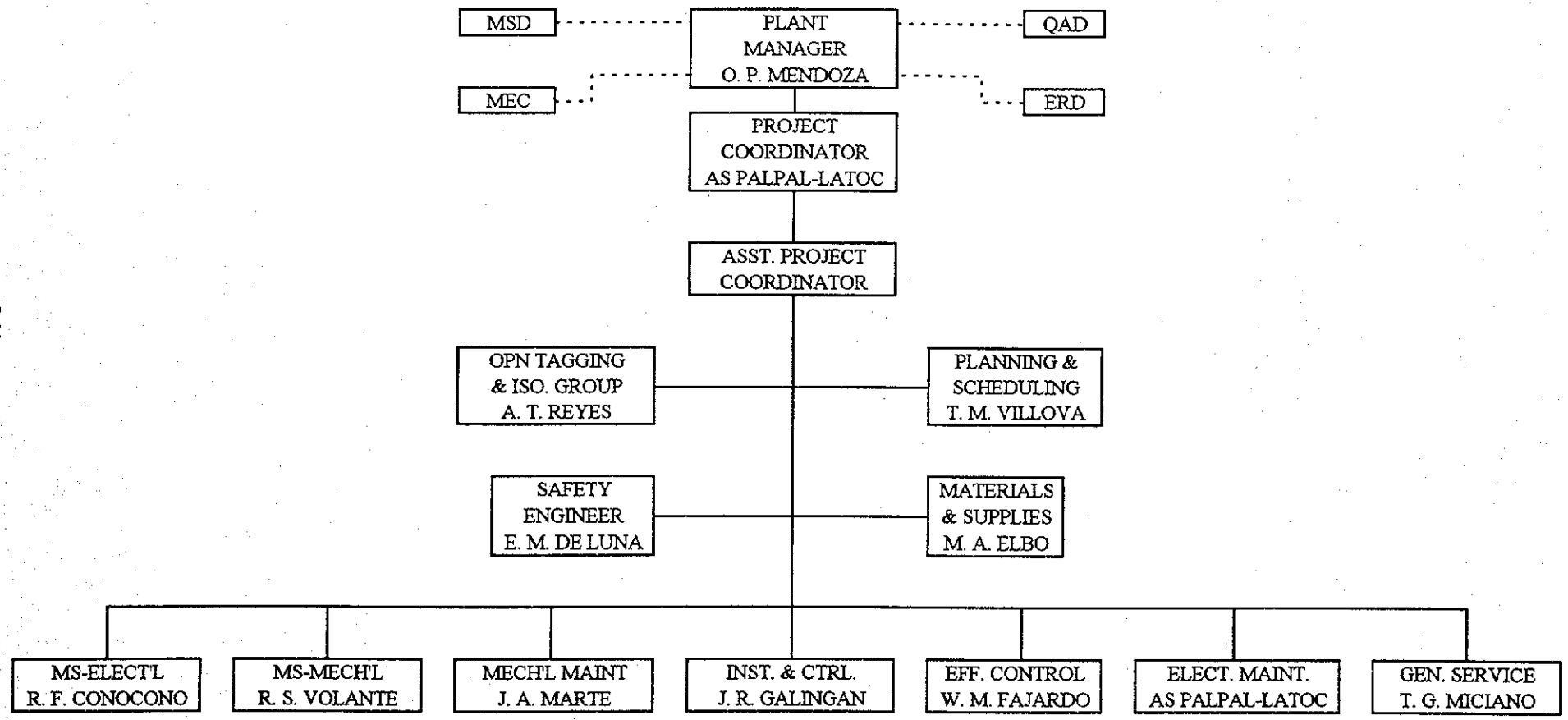


Table 5-7 Malaya Unit No. 1 Overhaul Table of Organization (September 1 to December 10, 1994)

			DUTIES AND RESPONSIBILITIES
1.0	PLANT MANAGER	-	OVERALL RESPONSIBLE FOR THE ACCOMPLISHMENT OF THE WHOLE PROJECT.
2.0	PROJECT COORDINATOR	-	COORDINATE/OVERSEE THE SMOOTH IMPLEMENTATION OF THE WHOLE PROJECT.
3.0	PLANNING AND SCHEDULING	-	ASSIST THE PROJECT COORDINATOR FOR THE SMOOTH IMPLEMENTATION OF EACH ACTIVITY. MONITOR THE PROGRESS OF WORKS. AND PREPARE WEEKLY OVERALL REPORT FOR UPPER MANAGEMENT INFORMATION.
4.0	OPERATION/ISOLATION AND TAGGING GROUP	-	RESPONSIBLE FOR THE OVERALL ISOLATION/TAGGING OF ALL SYSTEMS AND EQUIPMENT UNDER THE OVERHAUL PERIOD UP TO THE START-UP OF THE UNIT.
5.0	SAFETY ENGINEER	-	ASSIST THE PROJECT COORDINATOR IN OVERSEEING/MONITORING THE ADHERENCE TO SAFETY RULES AND PRACTICES OF ALL PERSONNEL/WORKING GROUPS INVOLVED IN THE OVERHAULING.
6.0	FUNCTIONAL WORKING GROUPS 6.1 MECHANICAL MAINTENANCE 6.2 ELECTRICAL MAINTENANCE 6.3 INSTRUMENTS AND CONTROL 6.4 EFFICIENCY AND CONTROL 6.5 GENERAL SERVICES 6.6 OTHERS (MS. TS. ETC.)		RESPONSIBLE FOR THE ACCOMPLISHMENT OF ALL ACTIVITIES ASSIGNED UNDER HIS GROUP. PREPARE DAILY/WEEKLY ACCOMPLISHMENT REPORT AND FORWARD TO PLANNING AND SCHEDULING GROUP FOR FINAL CONSOLIDATION.
7.0	MATERIALS AND SUPPLIES GROUP	-	ASSIST THE PROJECT COORDINATOR FOR THE ISSUANCE OF NECESSARY MATERIALS/EQUIPMENT NEEDED BY EACH WORKING GROUP.

APPROVED

ORLANDO P. MENDOZA
Plant Manager

k. Authorities for Contracting and Acceptance of Materials for Overhaul Works

a) Acquisition of Budget

- As for the annual budget, the budget for the next fiscal year is applied to MMRC in May-June period and decision is made in December.
- The purchase of parts used in works controlled by MSD and the purchase of raw materials for parts produced by MEC for power plants are covered by the budget of each power plant.

b) Procedure for Contracting and Authorities

- The articles necessary for overhaul are arranged by the power plant including those for works controlled by MSD. However, specification, purchase quantity, etc. are advised from MSD.
- Various expenses such as personnel expenses of the manpower dispatched from MSD to power plants are expenses of MSD.
- Authorities for contracting amount in pesos

Power plant manager:	Up to 100,000 peso
Vice President of MMRC:	Up to 5,000,000 peso
President:	Up to 50,000,000 peso
Board:	Over 50,000,000 peso

- Contracting for materials and works of over 100,000 peso is made by MMRC based on requests from the power plant. For the items exceeding the authorities of MMRC Vice-President, proceedings for purchase are made at MMRC and direct application of the purchase is made to the president from MMRC.

5) Method for Subcontracting of Overhaul and Preventive Maintenance Works

a. Subcontractors of MSD

MSD employs welders, pipe fitters, semi-skilled workers, helpers, etc. during overhaul to make up shortage of the manpower.

a) 10 ~ 20 persons qualified for welding of high pressure parts are employed from WITCO (Welding Inspection and Testing Company).

b) 20 ~ 30 structural welders are employed for performing welding of ducts, structures, etc.

c) WITCO's pipe fitters are employed. They perform piping works, scaffolding, etc. under the supervision of MSD supervisors.

d) X-ray inspection is contracted with III, WITCO, ECOASIA or others. X-ray inspection is entirely conducted on welded seams of high pressure portions. MT and UT are conducted by MSD. PT is also conducted by the power plant.

b. Production of Parts at MEC

MEC also manufactured boiler panels. But since the number of persons qualified for welding of high pressure portions is only four at MEC, qualified welders are employed from WITCO and BHPI (Babcock Hitachi Philippines Inc.).

c. Subcontracting at Power Plant

There was no case of subcontracting for daily maintenance. Daily maintenance is entirely implemented by the Maintenance Group of the power plant. The power plant also hires workers as helper at the time of overhaul.

6) Data and Drawing Management

Data and Drawings are stored in cabinets and shelves at the Technical Document Center (T.D.C.). The drawings are initially classified into three major categories, i.e. local, boiler and turbine, and relevant lists have been prepared. The staff in charge of T.D.C. can find the documents quickly, though others may have some difficulty.

The data are generally classified into each facility, and simply stored without any registration or circulation routes being established.

The retention periods of the documents and data have been set, e.g. the drawing and test data will be permanently stored. Electrical and instrumentation data is not managed at the T.D.C., but is kept by the respective section in charge.

A request has been submitted to the Plant Manager so that one copy of each document can be kept at T.D.C. The T.D.C. plans to use filing shelves with addresses to store data in a proper order.

As the stored data and drawings has to be accompanied by other relevant data and drawings, it is necessary to have T.D.C. keep them in centralized manner and implement a management method that enables simplified search.

Feedback from a modification of data and drawings are kept together with the modified data and drawings, separately from the originals. After the modification work, the original data and drawings should be revised.

Lending of data and drawings are possible by signing the borrowing note prepared by the T.D.C. staff in charge.

5.1.3 Chemical Management

1) Water Quality Standard and Analytical Result during Unit Operation

Tables 5-8, 5-9 and 5-10 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 5-8 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 5-9 House Service Water Quality Standard Value (using Demineralized water)

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

Table 5-10 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 5-11, 5-12, and 5-13.

Table 5-11 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 5-12 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

Table 5-13 Chemical Section Daily Activities

M-1 & M-2 DAILY ACTIVITIES	DAY	MON			TUES			WEDNES			THUS			FRI			SATUR			SUN			FREQUENCY
	SHIFT	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
A. SAMPLING AND ANALYSIS																							
a)C^-, N_2H_4, SiO_2, PO_4, COND, Na		o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	Every 4 Hrs
b)fe (at ECO.)			o												o								Once
c) Cu (at ECO & C. P.)			o												o								Once
d) D. O. (at ECO C. P.)			o			o			o			o			o			o			o		Once
e) STATOR COOLING WATER)				o			o			o			o			o			o			o	Once
f) CATHODIC PROTECTION			o						o						o								Once
g) DEEPWELL/FILTERED WATER									o														Once
h) LAKEWATER							o																Once
i) SETTLING BASIN			o			o			o			o			o			o			o		Once
j) COOLING WATER																							Once
B. OPERATION PER SOP																							
a)PRIMARY WATER TREATMENT PLANT-ODP																							Any Shift as Regd
b)SECONDARY WATER TREATMENT PLANT																							Any Shift as Regd
c)PRIMARY WATER TREATMENT PLANT-PDO																							Same
C. CHARGING OF CHEMICAL																							
a)BOILER & PRE-BOILER WATER TREATMENT																							Any Shift as Regd
b)H. S. C. S.												o											AS Regd
c)LAKEWATER CHLORINATION			o						o						o								Everyday
D. INVENTORIES-CONSUMPTIONS																							
a)NaOH, H_2SO_4, NH_4OH, NaOCl		o			o			o			o			o			o			o			AS Regd
b)DEM. WATER PRODUCTION AND STOCK																							Every Shift/as Regd
c)CHEMICAL REAGENTS																							AS Regd
d)LABORATORY SUPPLIES																							AS Regd
E. HOUSEKEEPING																							
a)CHEMICAL LABORATORY																							Every Shift
b)PDP AREA																							Every Shift
c)AMMONEX AREA																							AS Regd
d)SAMPLING RACK M-1 & M-2																							
e)CHEMICAL INJECTION PUMP AREA M-1 & M-2																							AS Regd Every Shift
F. OTHER ROUTINE JOB																							
a)H. S. G. S. SAMPLING AND ANALYSIS																							Once
b)NH_3 ANALYSIS OF M-1																							Once
c)CALIBRATION OF M-1 SAMPLING RACK																							Every 15th & 16th
INSTRUMENT (pH.DO_2.COND.N_2H_4)																							of the Month
d)CALIBRATION OF M-2 SAMPLING RACK																							
INSTRUMENT (pH.DO_2.SiO_2 & COND)																							17th & 18th of the Month
e)CALIBRATION OF ALL LAB INSTRUMENTS																							
(Na ANALYSER.pH & COND METER)																							Every 15th of the Month
f)CHARGING OF CHEMICALS TO PRE-TREAT-																							
MENT PLANT																							
g)SAMPLING & ANALYSIS OF FUEL ADDITIVE																							
PARAMETERS																							

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 5-8, 5-9, 5-10, 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. Status and conductivity of the water from each well are as listed in Table 5-14. Table 5-15 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 5-14 Use and Conductivity of Deep Wells

Deep Well No.	Use	μS/cm (Analysis Data Sep. 1944)
1	for house service water	706
2	for gas turbine water	–
3	not used	–
4	not used	–
5	for thermal plant water	605
6	for thermal plant water	814
7	for thermal plant water	–
Filter water	for thermal plant water	724*
* Mixed water from No. 5 and No. 6 wells		

Table 5-15 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. The quality of demineralized water sampled during first site survey is given in Table 5-17. This data shows that the colloidal silica content is 0.02 mg/ℓ, which is the standard limit.

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. This quantity is enough for the time of unit start-up which requires an enormous amount of demineralized water. Table 5-16 shows the list of demineralized water tanks.

Table 5-16 List of Demineralized Water Tank

Tank No.	Capacity (Ton)
1	570
2	450
3	1,140
4	1,140
5	570
Organo Demine. Tank	210
Total	4,080

Table 5-17 Analytical Data of Demineralized Water Quality

Item	Unit	Analytical Data	Standard
Conductivity	μS/cm	–	0.20
Na	mg/ℓ	0.00028	
K	mg/ℓ	<0.00002	
Ca	mg/ℓ	0.00033	
Al	mg/ℓ	<0.005	
Cl	mg/ℓ	0.00007	
SO_4	mg/ℓ	0.00040	
Total -SiO_2	mg/ℓ	0.02	0.02
Colloidal -SiO_2	mg/ℓ	0.02	
Soluble -SiO_2	mg/ℓ	<0.01	

d. Condensate Polisher

As the M-1 is a once-through boiler, a condensate polisher is installed. Operation of condensate polisher is satisfactory. Table 5-18 shows an example of the data sheet for the M-1 condensate polisher.

Table 5-18 Example of M-1 Condensate Polisher Data Sheet

DATE: JUNE 14 1994

DATA SHEET FOR M-1 CONDENSATE POLISHER

ITEM / TIME AND DATE		RESIN	MAX	1AM	4AM	7AM	10AM	1 PM	4PM	7PM	10PM
FLOW RATE GPM+10	A	R-3	140				—	—			
	B	R-4	140	71	71	70	70	70	70	70	70
	C	R-5	140				—	—			
	D	R-1	140	80	81	82	79	82	81	80	86
FLOW COUNT Gallons/min x10	A		NEW				—	—			
	B		4 DAYS	21643	22500	23415	24194	25111	25823	26588	27502
	C		CAP				—	—			
	D		6 DAYS	44949	45998	46880	47732	48733	49540	50348	51345
CONDUCTIVITY uS/CM	INLET		6.4	4.36	4.32	4.3	4.3	4.3	4.3	4.32	4.6
	OUTLET		0.2	.100	.093	.095	.10	.092	.100	.100	.100
	A		0.2				—	—			
	B		0.2	.089	.087	087	.088	.082	.088	.090	.090
	C		0.2				—	—			
	D		0.2	.093	.093	093	.092	.084	.092	.097	.097
DIFF. PRESS	PSI.		50	0	0	0	0	0	0	0	0
INLET TEMP.	°F		120	111	111	111	110	111	111	111	112

SHIFT / TIME	REMARKS
11PM-7AM SHIFT	R-2 FOR INTRO
7AM - 2PM SHIFT 37662145 37646280 15,865	Performed chemical intro to R-2 for cleaning #2
2PM - 11PM SHIFT 37663400 37602145 1355	R-2 ON AMMONIATION @ 7PM

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 5-19.

Table 5-19 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 5-20.

Table 5-20 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.

Figure 5-4 M-1 Condenser Water Box Conditions (1/2)

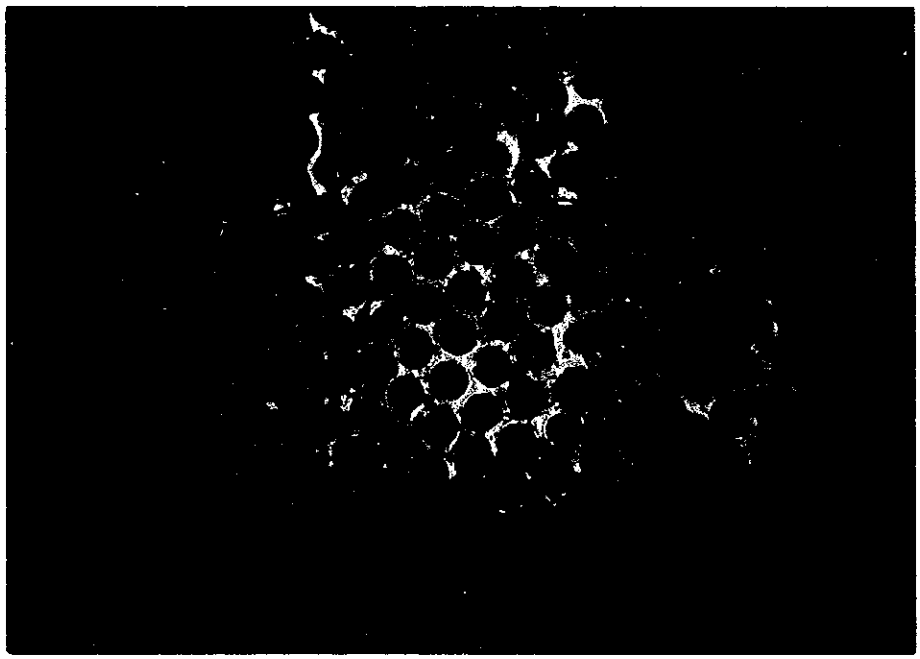


Figure 5-4 M-1 Condenser Water Box Conditions (2/2)

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 given in Table 5-21.

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.

Table 5-21 Equipment Preservation Methods (1/5)

EQUIPMENT	OUTAGE PERIOD	STANDARD METHOD		ALTERNATIVE METHOD		REMARKS
		ONCE-THRU UNITS	CONVENTIONAL UNITS	ONCE-THRU UNITS	CONVENTIONAL UNITS	
1. Boiler Circuits	< 100 hrs.	Wet Storage N_2H_4 = 5-10 ppm	- Hot Banking, when cooling is not necessary. - Wet Storage, when cooling down is necessary.		- Intermittent firing, when cooling down is not necessary. - Nitrogen Blanketing, when cooling down is necessary.	Refer to the attached procedures.
	> 100 hrs. < 10 days	Wet Storage N_2H_4 = 10-20 ppm	Wet Storage N_2H_4 = 10-20 ppm	N_2 purging and Blanketing	same as above	
	> 10 days < 1 mo.	Wet Storage N_2H_4 = 50 ppm NH_3 = 5 ppm pH > 10	N_2 purging and blanketing	- do -	Wet Storage N_2H_4 = 20-30 ppm	
	> 1 month	N_2 Purging and blanketing	Dry Storage with Desiccant	Wet Storage N_2H_4 = 100 ppm NH_3 = 5 ppm pH > 10	Wet Storage N_2H_4 = 20-30 ppm	
2. Superheater	< 100 hrs.	N_2 Purging and Blanketing	- N_2 Purging and Blanketing, when cooling down is necessary. - Hot Banking, when cooling down is not necessary.	Wet Storage N_2H_4 = 5-10 ppm	Intermittent Firing when cooling down is not necessary.	

Table 5-21 Equipment Preservation Methods (2/5)

EQUIPMENT	OUTAGE PERIOD	STANDARD METHOD		ALTERNATIVE METHOD		REMARKS
		ONCE-THRU UNITS	CONVENTIONAL UNITS	ONCE-THRU UNITS	CONVENTIONAL UNITS	
2. Superheater (cont.)	> 100 hrs. < 10 days	N_2 Purging and blanketing	N_2 Purging and blanketing	Wet Storage N_2H_4 = 10-20 ppm NH_3 = 5 ppm pH > 10		
	> 10 days < 1 month	N_2 Purging and blanketing	N_2 Purging and blanketing	Wet Storage N_2H_4 = 50 ppm NH_3 = 5 ppm pH > 10	Wet Storage N_2H_4 = 50 ppm	
	> 1 month	N_2 Purging and Blanketing	Dry Storage with Desiccant	Wet Storage N_2H_4 = 100 ppm NH_3 = 5 ppm	Wet Storage N_2H_4 = 100 ppm	
3. Reheater	< 10 days	N_2 Purging and Blanketing	- Hot Banking, when cooling is not necessary. - N_2 Purging and Blanketing, when cooling down is necessary.		- Intermittent firing, when cooling down is now necessary. - N_2 Purging and Blanketing, when cooling down is necessary.	Refer to the attached procedures.
	> 10 days	N_2 Purging and blanketing	N_2 Purging and Blanketing			
4. Deaerator	< 100 hrs.	Storage Tank: Wet Storage N_2H_4 = 5-10 ppm Deaerating Heater: N_2 Blanketing				

Table 5-21 Equipment Preservation Methods (3/5)

EQUIPMENT	OUTAGE PERIOD	STANDARD METHOD		ALTERNATIVE METHOD		REMARKS
		ONCE-THRU UNITS	CONVENTIONAL UNITS	ONCE-THRU UNITS	CONVENTIONAL UNITS	
4. Deaerator (cont.)	> 100 hrs. < 10 days	Storage Tank: Wet Storage N_2H_4 = 5-10 ppm Deaerating Heater: N_2 Blanketing Except N_2H_4 = 10-20 ppm				Refer to the attached procedures.
	> 10 days < 1 month	Same as above Except:				
		N_2H_4 = 50 ppm NH_3 = 5 ppm pH > 10	N_2H_4 = 20-30 ppm			
	> 1 month	Dry Storage with Desiccant for both tank and heater.		Storage Tank: Wet Storage		
				N_2H_4 = 100 ppm NH_3 5 ppm, pH > 10	N_2H_4 = 20-30 ppm	
				Deaerating Heater: Nitrogen Blanketing		
5. Feedwater Heaters, LPH/HPH (Shellside)	< 100 hrs.	Steam or N_2 Blanketing		Wet Storage N_2H_4 = 5-10 ppm		
	> 100 hrs. < 10 days	Same as above		Wet Storage N_2H_4 = 10-20 ppm		

Table 5-21 Equipment Preservation Methods (4/5)

EQUIPMENT	OUTAGE PERIOD	STANDARD METHOD		ALTERNATIVE METHOD		REMARKS
		ONCE-THRU UNITS	CONVENTIONAL UNITS	ONCE-THRU UNITS	CONVENTIONAL UNITS	
5. Feedwater Heaters, LPH/HPH (Shellside) (cont.)	> 10 days < 1 month	N_2 purging and blanketing		Wet Storage		Refer to the attached procedures.
				N_2H_4 = 50 ppm NH_3 = 5 ppm pH 10	N_2H_4 = 20-30 ppm	
	> 1 month	N_2 purging and blanketing		Wet Storage		
				N_2H_4 = 100 ppm NH_3 = 5 ppm pH > 10	N_2H_4 = 20-30 ppm	
6. Main/Aux. Condenser	< 10 days	Shell Side: Flooding N_2H_4 = 10-20 ppm Tube Side: Manual Cleaning		Shell Side: Dry Lay-up with hot air circulation Tube Side: Manual Cleaning		Refer to the attached procedures.
	> 10 days < 1 month	Shell Side: Flooding N_2H_4 = 20-30 ppm Tube Side: Manual Cleaning including drying and painting of water boxed		Same as above		
	> 1 month	Shell Side: Dry lay-up with hot air circulation Tube Side: Manual Cleaning including drying and painting of water boxes		Shell Side: Dry lay-up with desiccant Tube Side: Manual Cleaning including drying and painting of water boxes		
7. Turbine	> 1 month	Hot Air Circulation				

Table 5-21 Equipment Preservation Methods (5/5)

EQUIPMENT	OUTAGE PERIOD	STANDARD METHOD		ALTERNATIVE METHOD		REMARKS
		ONCE-THRU UNITS	CONVENTIONAL UNITS	ONCE-THRU UNITS	CONVENTIONAL UNITS	
8. Generator	during overhaul	Stator - Heating Rotor - Enclosure with desiccant				When generator is dismantled.
9. Exciter	> 1 month	Static - Dry lay-up with desiccant Rotating - Hot air circulation				
10. 4160V Motors	> 1 month	Heating				Refer to the attached procedures
11. Air Heater and Dust Collector	< 10 days	Washing and drying if ΔP across air heater exceeded allowable limit				
	> 10 days	Washing and drying even if ΔP limit is not exceeded				
12. Steam Coil Air Heater (SCAH)	< 10 days	Steam Sealing		Nitrogen Blanketing		Refer to the attached procedures
	> 10 days	Nitrogen Blanketing				
13. Force Draft Fan (FDF)	< 1 month		Water washing and drying			
14. Gas Recirculation Fan (GRF)	> 1 month	Water Washing, Drying and Painting				
15. Demi-Plant Resins	> 1 week < 1 month > 1 month	Exhaust and Drain. Do not allow to dry. Exhaust and immerse in 10% NaCl solution				

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) are shown in Tables 5-22 and 5-23.

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.

Table 5-22 Start-up Water Quality Standard of M-1 (Once through Boiler)

SAMPLING POINT		CP OUT			AMMONEX OUT			DEAERATOR OUT				ECONOMIZER INLET							FLASH TK	MAIN STEAM	
ANALYSIS ITEM / START-UP STEP		pH	Fe	DO_2	Fe	SiO_2	µS/cM	pH	Fe	DO_2	N_2H_4	pH	Fe	DO_2	N_2H_4	Cu	SiO_2	µS/cM	Fe	Fe	SiO_2
1	HOTWELL FLUSHING		< 500	< 200																	
2	LP SYSTEM FLUSHING		< 500	< 100					< 500	< 50	1000*										
3	LP CLEAN UP (LPCU)		< 100	< 100	< 50	< 20	< 0.3		< 100	< 50	1000*										
4	HP SYSTEM FLUSHING		< 100	< 100	< 50	< 20	< 0.3		< 100	< 10	1000*		< 100	< 10	*			< 1.0	< 500		
5	HP COLD CLEAN UP (HPCCU)		< 100	< 100	< 50	< 20	< 0.3		< 100	< 10	*		< 100	< 10	*		< 50	< 1.0	< 100		
6	HP HOT CLEAN UP (HPHCU) 374F	9.2 to 9.4	< 50	< 50	< 50	< 20	< 0.3	9.2 to 9.4	< 50	< 10	50 - 100	9.2 to 9.4	< 50	< 10	50 to 100	< 10	< 50	< 0.5			
	HP HOT CLEAN UP (HPHCU) 500																				
	HP HOT CLEAN UP (HPHCU) 550F 600F 630F		< 50	< 50	< 20	< 20	< 0.3		< 50	< 10	50 - 100		< 50	< 10		< 10	< 50 < 30 < 30	< 0.5		< 40	< 40
7	SYNCHRONIZATION UP TO 1/2 LOAD		< 20	< 20	< 10	< 20	< 0.2			< 7	10 - 30		< 30	< 7	10 - 30	< 5	< 30	< 0.5		< 30	< 30
8	FULL LOAD		< 10	< 20	< 10	< 20	< 0.2			< 7	10 - 30		< 10	< 7	10 - 30	2	< 20	< 0.3		< 10	< 20

NOTE: All units in parts per billion (ppb) except pH and conductivity.
All conductivity values are passing through cation resin.

* 1 - 3 PPM N_2H_4

Table 5-23 Start-up Water Quality Standard of M-2 (Drum Type Boiler)

	CP OUT			DEAERATOR OUT			HP FEEDWATER/ ECO. INLET				BOILER SALINE				SAT'D/MAIN STEAM	
ANALYSIS ITEM / STEP	pH	cation µs/cm	Fe ppb	cation µs/cm	Fe ppb	DO_2 ppb	cation µs/cm	Fe ppb	DO_2 ppb	N_2H_4 ppb	pH	Direct µs/cm	SiO_2 ppm	Fe ppb	cation µs/cm	SiO_2 ppm
HOTWELL FLUSHING			< 500	-	-	-	-	-	-	-					-	-
LP SYSTEM FLUSHING	8.6 - 8.9	-	< 500	-	< 500	< 50	-	-	-	-					-	-
BOILER FLUSHING **	8.6 - 8.9	1.0	< 500	< 1.0	< 100	< 50	< 1.0	< 100	< 50	1000 - 3000			*	< 300b	-	-
BOILER FIRING & PRESSURIZATION	8.6 - 8.9	1.0	< 100	< 1.0	< 100	< 10	< 1.0	< 100	< 50	50 - 100	8.9 - 9.25		*		-	-
TURBINE ROLLING & SYNCHRONIZATION TO 1/2 LOAD	8.6 - 8.9	0.5	< 50	< 0.5	< 50	< 10	< 0.5	< 20b	< 7	10 - 30	8.9- 9.25	< 20	< 0.2		< 0.5	20
FULL LOAD	8.6 - 8.9	0.5	< 50	< 0.5	< 20	< 7	< 0.5	< 10b	< 7	10 - 30	8.9 - 9.25	< 20	< 0.2		< 0.5	20

NOTE: PO_4 injection starts at boiler flushing step to maintain 2-4 ppm at 2.6 Na to PO_4 ratio.
Total solids, conductivity and silica in excess of limit in drum water can be reduced by CBD.

* Silica limit according to drum pressure (from silica concentration vs. drum pressure curve).
** Flushing through downcomer bottom drain to waste

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 5-24 and 5-25.

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 5-24 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 5-25 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 5-26 shows the analytical results of the currently-consumed fuel oil (heavy oil) sampled during first site survey and brought back to Japan.

Table 5-26 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

Characteristics of the heavy oil, which is widely used as fuel for oil-fired boilers in Japan, are listed in Table 5-27.

Table 5-27 A Data Record of Heavy Oil Properties in Japan

Property / Description	Flash Point °C	Viscosity cSt (50°C)	Fluid Point °C	Residual Carbon wt%	Sulfur wt%	Specific Gravity 15/4°C	Calorific Value kcal/kg
Heavy Oil C							
A	more than 110	138	7.5	9.1	2.24	0.948	10,410
B	more than 110	138	7.5	9.2	2.23	0.948	10,450
C	110	106	15.0	8.8	2.32	0.945	10,420
D	more than 110	107	7.5	8.2	2.09	0.949	10,430
E	more than 110	127	10.0	9.1	2.31	0.949	10,420
F	96	101	7.5	9.3	2.57	0.947	10,460
G	more than 110	99	5.0	9.2	2.35	0.947	10,440
H	96	104	12.5	9.9	2.38	0.949	10,430
I	100	103	0.0	2.8	2.35	0.946	10,410
J	91	91	2.5	9.2	2.38	0.946	10,400
Low-Sulfur Heavy Oil							
A	104	81	less than -5	8.5	1.28	0.946	10,460
B	–	123	less than -5	–	1.58	0.957	10,370
C	94	95	15.0	6.6	0.86	0.943	10,460

For all items, 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 5-5 and Figure 5-6 respectively.

The outline of the restructuring plan is as follows:

Present organization	Organization Restructuring plan
- Operations	- Operations
Shift Operations-Power Plant Fuel Group	Shift Operations-Power Plant
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 Administration/Finance/Property	- Support Service 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 cannot be performed as scheduled because the planed overhaul schedule does not meet 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 5-5 Organization of Malaya Thermal Power Plant (Present Status)

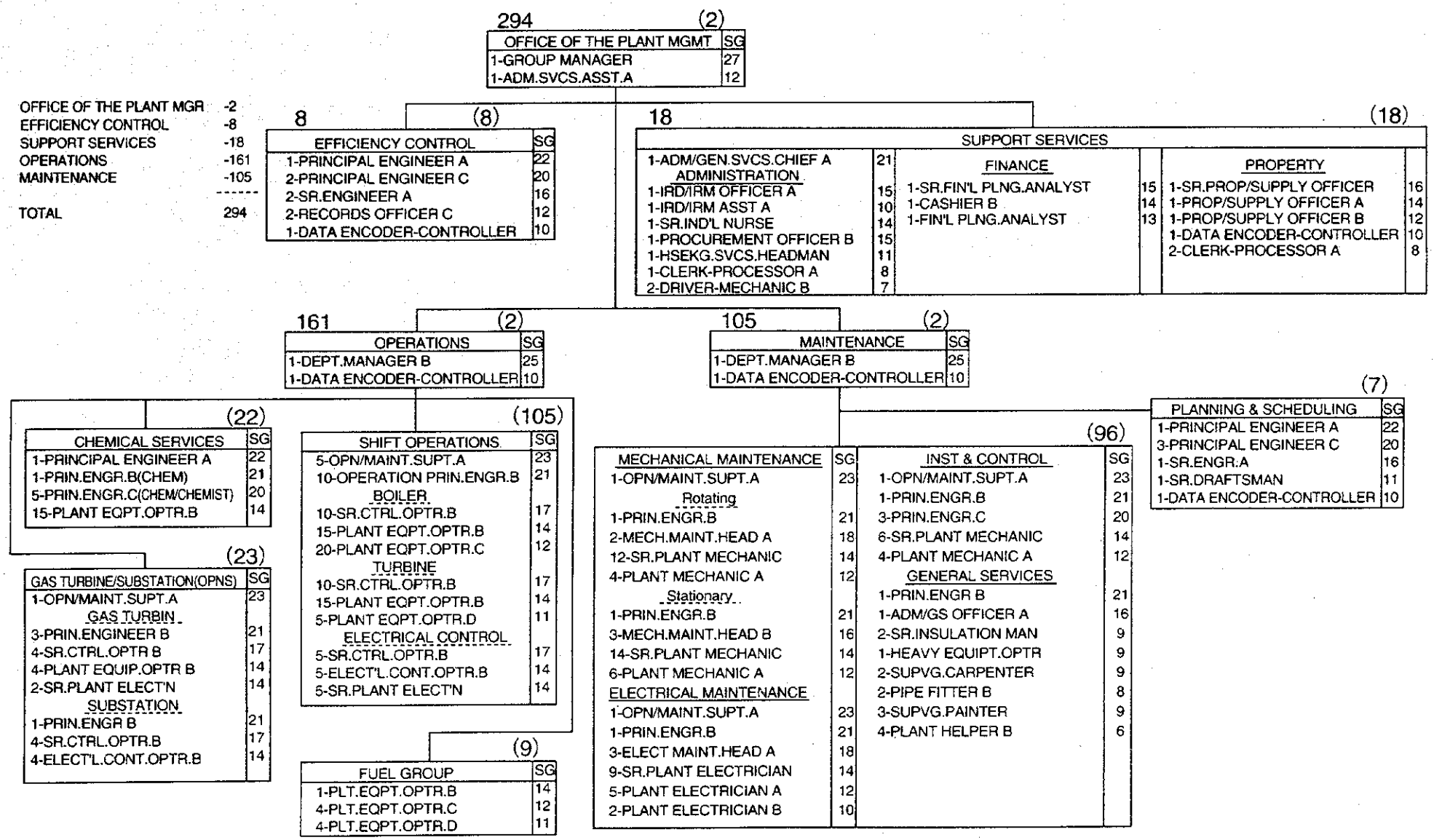
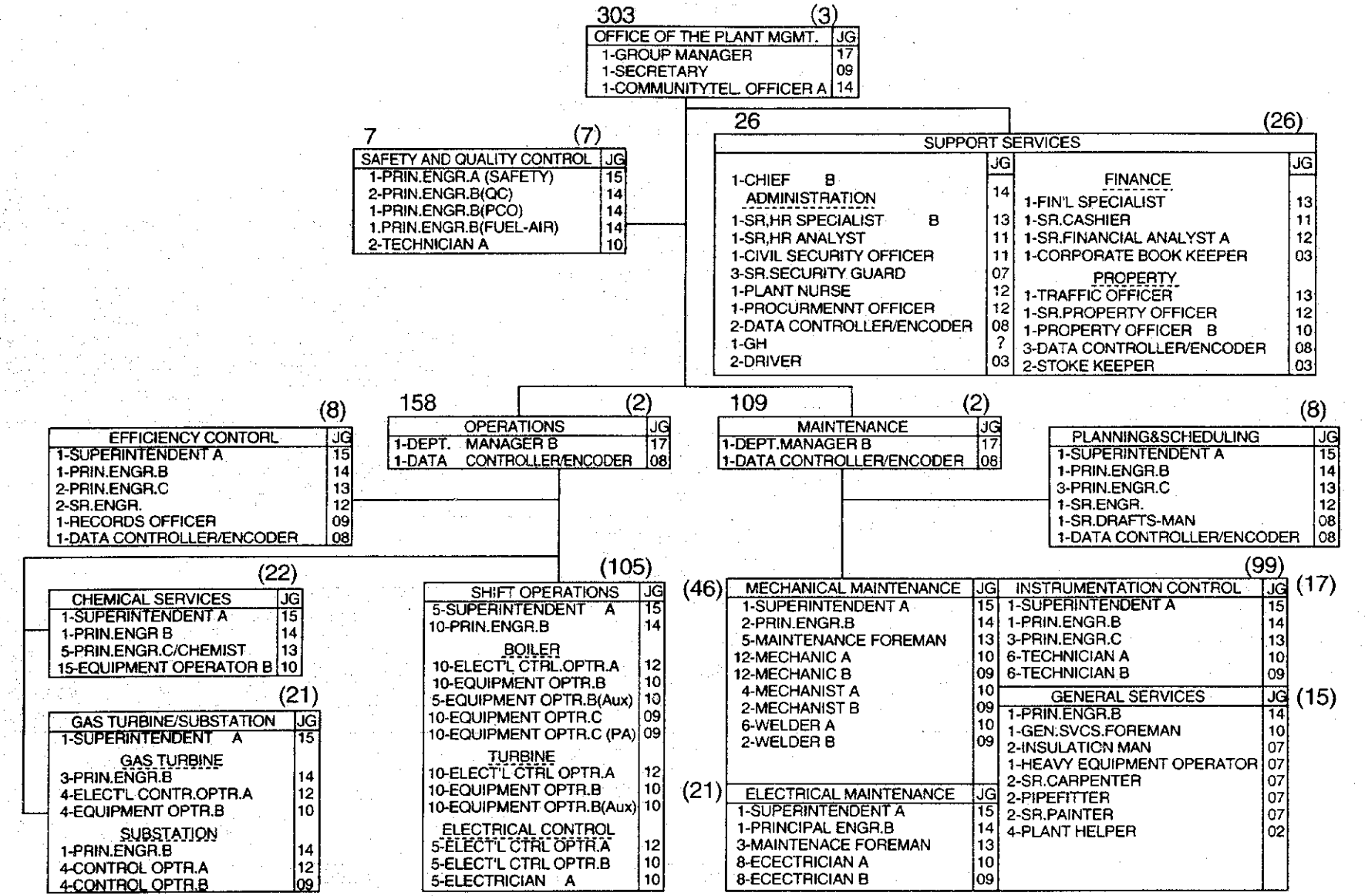


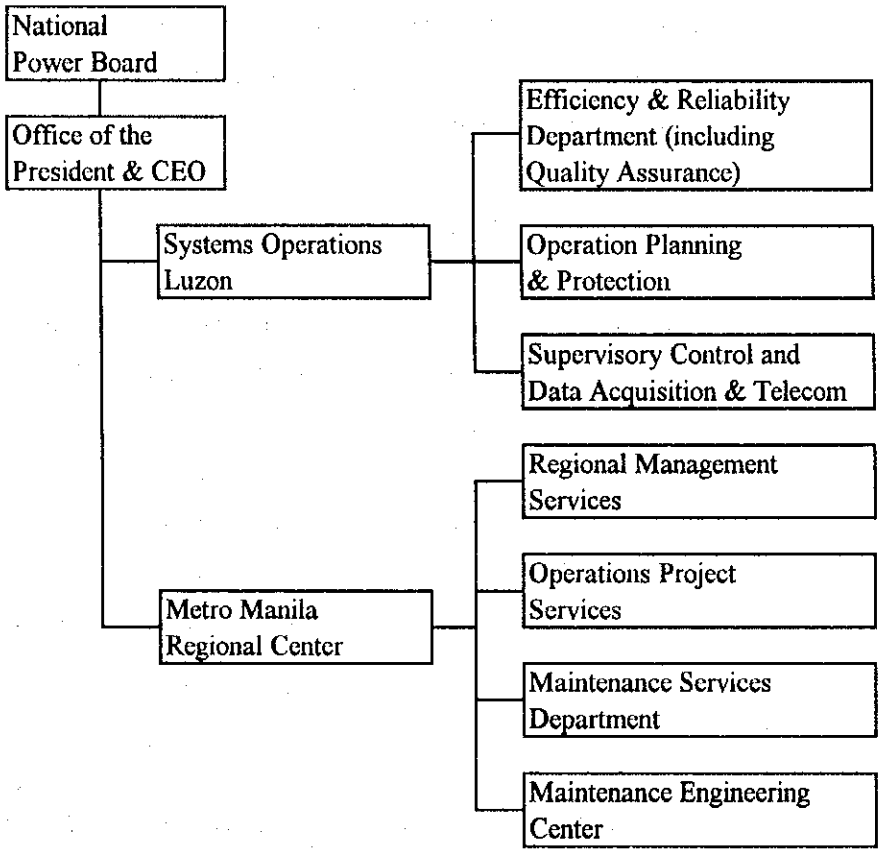
Figure 5-6 Organization of Malaya Thermal Power Plant (Plan)



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

The overall organization of NPC is as shown in Figure 3-3, and the departments related to operation and management of power plants are indicated below Figure 5-7.

Figure 5-7 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
- Study for improvement of plant efficiency and reliability
- 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

Five thermal power plants exist in Luzon grid; Bataan TPP, Manila TPP, Sucat TPP, Malaya TPP and Batangas TPP. Operation and maintenance of all of these thermal power plants including the Batangas TPP located in the territory of Southern Luzon Regional Center are entirely controlled and managed by Metro Manila Regional Center (MMRC). This MMRC consists of the following sections. See Figure 5-8.

a) Regional Management Services (RMS)

This department controls and manages technical matters and financial audits and environment matters of power plants. See Figure 5-9.

b) Operation Project Services (OPS)

This department totally manages design, technical study, operation plan and coordination and management of thermal power plants. 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. OPS is composed of five divisions, i.e., mechanical, electrical, chemical, computer services, efficiency management and data management. See Figure 5-10.

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 overhaul 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 organization of MSD is divided into three divisions, i.e., mechanical, electrical and support services. The mechanical division is further divided into boiler, turbine and auxiliary machine sections. The electrical division is further divided into generator, substation, relay and test/meter sections. See Figure 5-11.

The overhaul works for auxiliary equipment such as pumps, fans, sootblowers and valves are carried out by the maintenance group of the power plant. But the actual division of work between MSD and the plant maintenance group is adjusted by the work volume and manpower of both parties at that time.

Contracted workers are always supervised by MSD's supervisor. A typical case of contracted workers are described in the sub-clause 5.1.2 5) Method for Subcontracting of Periodic Overhaul and Preventive Maintenance Works. The inputs of MSD manpower for overhaul of the following power plants are indicated in Table

5-28 for reference. Major repair/replacement works are observed in the table.

- Batangas unit No. 1 Annual Overhaul 1994
- Malaya unit No. 2 Boiler WW, RH, SH Tube Replacement 1993
- Malaya unit No. 1 Turbine Overhaul 1994

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. MEC has an office and workshop beside the Sucat TPP, equipped with many workshop machines and testing equipment. The organization of MEC includes four divisions, i.e., workshop, engineering, quality control and support services, as shown in Figure 5-12.

a) Workshop

The workshop has four groups, i.e., electrical, machining shop, metal forming & welding, and foundry. The workshop conducts repair and fabrication of spare parts and components for power plants including reblading and balancing of turbines, machining and forming of boiler tubes and panels, forming and assembly of air heater elements, repair of water wheels and water gates and rebabbitting of large size bearings. The workshop also performs training of welders dispatched from power plants as well as qualification based on ASME Section 9.

For fabrication of boiler panels, pressure vessels and others, MEC obtains technical cooperation from a boiler manufacturer in the Philippine.

b) Engineering Division

The engineering division has production engineering, non-destructive & material testing, and chemical laboratory groups. The production engineering group performs development of production plans, preparation of shop drawings and assembly drawings as well as planning and design related to technical improvements. The non-destructive & material testing group performs non-destructive inspection and materials testing. This group also performs training as

well as qualification of NPC technical staffs on non-destructive test of penetrant test (PT) and magnetic particle test (MT). The chemical laboratory group has an laboratory within the office and performs inspection and various testing.

e. Power Plant Management Organization in Japan

There is a thermal power department in an organization of the Head Office, for example, at one of the electric power utilities in Japan. This department executes entire management of power plants including construction planning and design as well as maintenance and operation management. The MMRC role of NPC are also included in the duties of the department stated above in this case.

Figure 5-13 indicates the structure of authorities and responsibility at the time of periodic overhaul. Total management of activities and budget of periodic overhaul work is made by the thermal power operation section in the thermal power department. (The methods for application for budget and decision are almost the same as those of the case of NPC.) The periodic overhaul are implemented under full responsibility of the maintenance section of the power plant. The maintenance section of the power plant executes managing and supervising, and actual work is performed by contractors. What is noteworthily in the case of Japan is that there are legally compulsory inspection items in the periodic overhaul of major equipment such as boilers and turbines, and inspection is conducted by the government authority, Ministry of International Trade and Industry, for approval during periodic overhaul.

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.

Application for budget for the next fiscal year is made to MMRC from each power plant in May or June, and decision is made around December.

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

Since application to the NPC president is directly made from MMRC for goods of amounts which exceed the authority of Vice President of MMRC these days, now it is possible to make arrangement for all of necessary goods under the authority of MMRC.

(Relevant description: Sub-clauses 5.1.2 2) "Daily Maintenance" and 5.1.2 4) "Overhaul Procedure and Implementation Structure")

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.

But as described in the clause 5.2.2 3) "Recommendation related to Periodic Overhaul and Preventive Maintenance Planning", decision of the time of periodic overhaul and unit shutdown are nonsense if overhaul cannot be started due to shortage of manpower of MSD. It is desirable that decision is made with the available manpower for overhaul fully taken into account. SOD should make decision upon sufficient discussion with relevant parties.

Figure 5-8 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
T O T A L	-	2,252

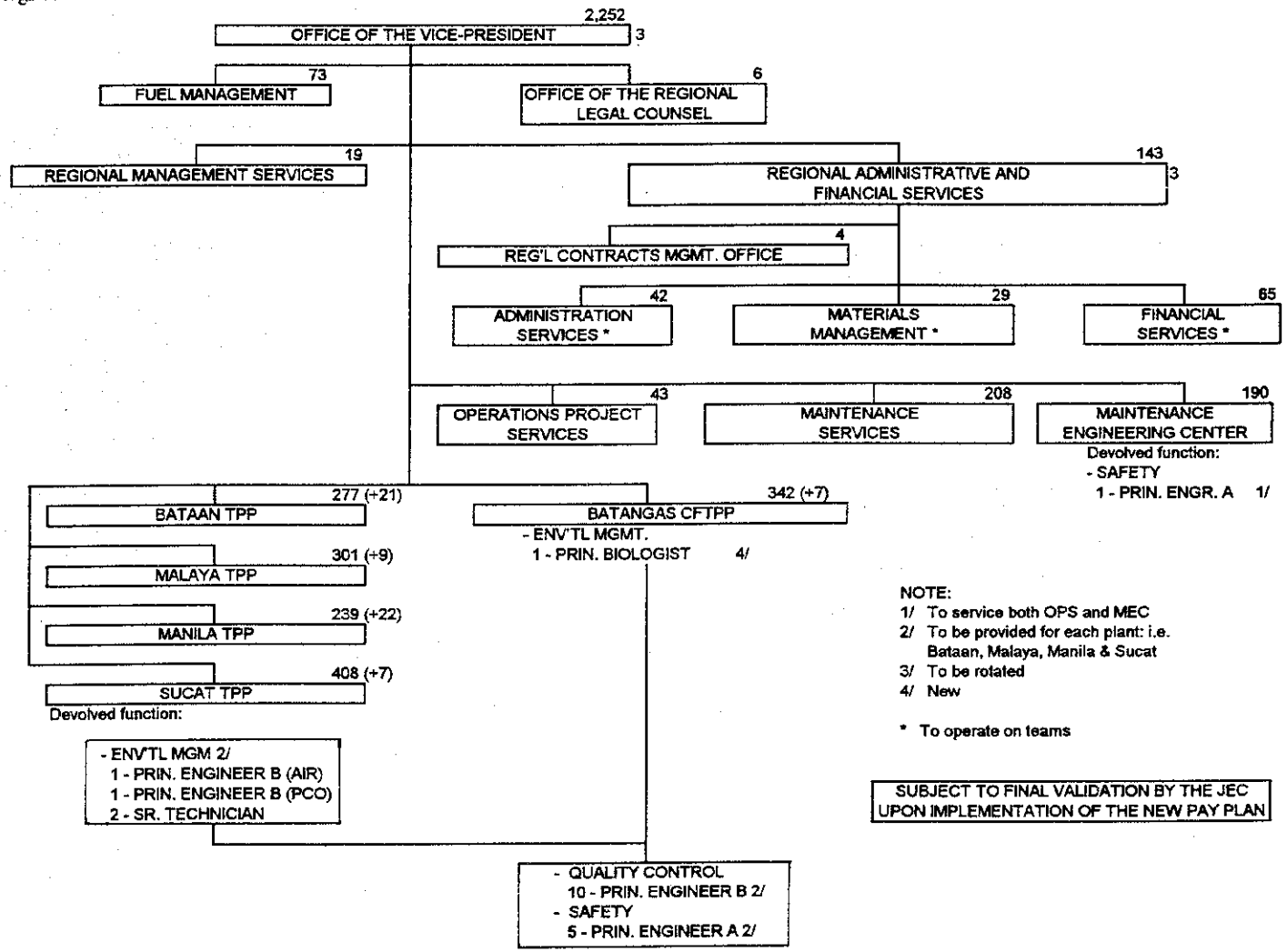


Figure 5-9 Organization of Office of The Vice-President - MMRC

SUMMARY:

Immediate OVP	-	3
Regional/Management Service	-	19
ORLC	-	6
Fuel Mgmt. Dep't	-	73
TOTAL	-	101

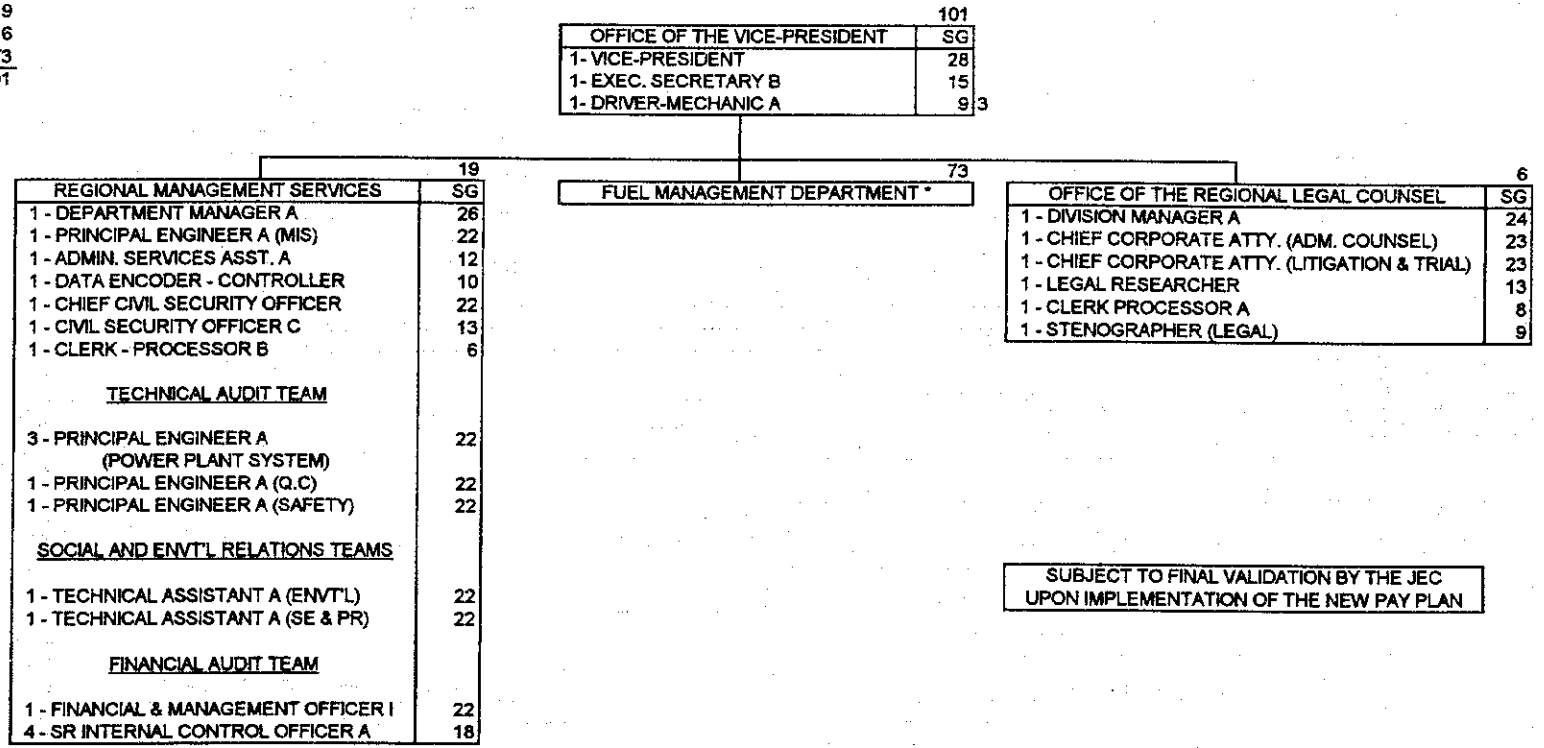
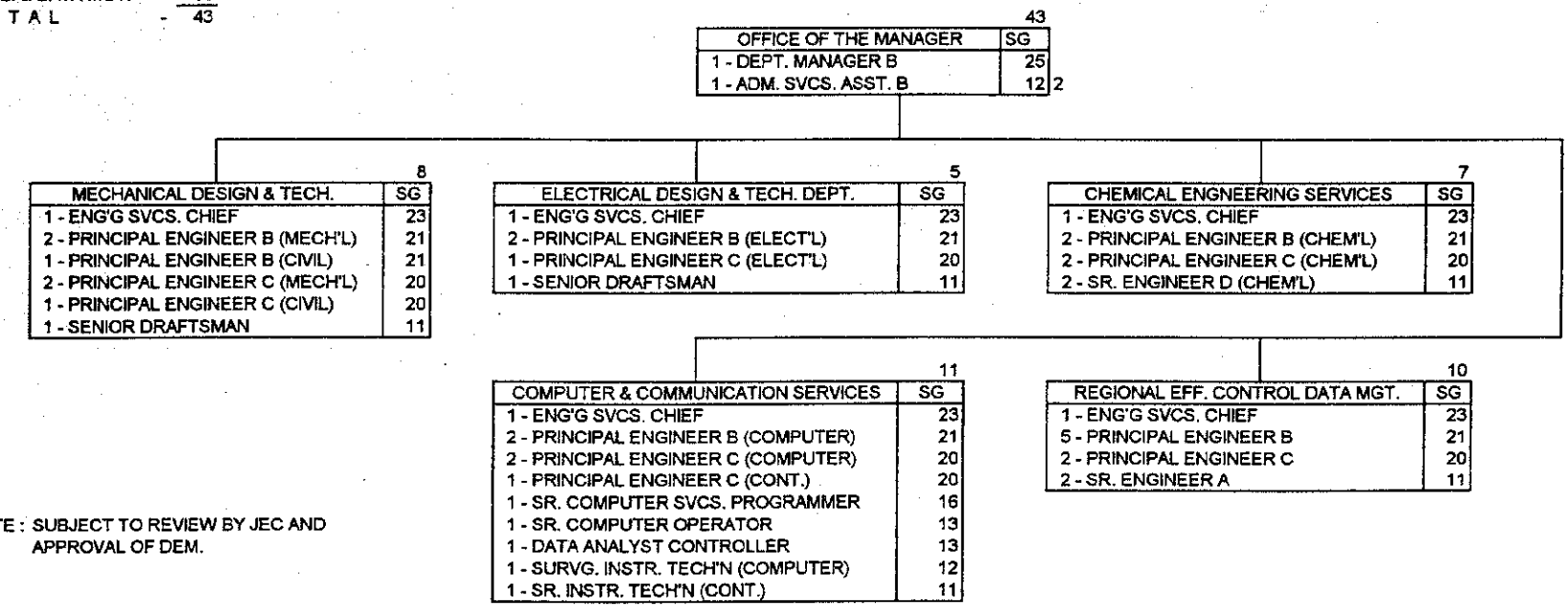


Figure 5-10 Organization of Operation Projects Services (OPS)

OFFICE OF THE MANAGER	-	2
MECH. DESIGN & TECH. DEPT.	-	8
ELECT. DESIGN & TECH. DEPT.	-	5
CHEMICAL ENG'G SVCS.	-	7
COMPUTER & COMM. SVCS.	-	11
REG. EFF. CTRL. & DATA MGT.	-	10
T O T A L	-	43



NOTE : SUBJECT TO REVIEW BY JEC AND APPROVAL OF DEM.

Figure 5-11 Organization of Maintenance Service Department (MSD)

SUMMARY:

OFFICE OF THE MANAGER	-	2
MECHANICAL MAINTENANCE	-	130
ELECTRICAL MAINTENANCE	-	51
SUPPORT SERVICES	-	26
T O T A L	-	209

209

OFFICE OF THE MANAGER	SG
1 - GROUP MANAGER	27
1 - ADM. SVCS. ASST.	12

2

130

MECHANICAL	SG
1 - DEPT. MANAGER B	25
1 - ADM. SVCS. ASST. A	12
BOILER	
1 - OPN./MAINT. SUPT. A	23
2 - PRIN. ENGR. B	21
BOILER PROPER	
1 - MAINTENANCE HEAD A	18
14 - SR. PLANT MECHANIC	14
3 - PLANT MECHANIC A	12
1 - PLANT MECHANIC C	8
BOILER ACCESSORIES	
2 - MAINTENANCE HEAD A	18
15 - SR. PLANT MECHANIC	14
4 - PLANT MECHANIC A	12
TURBINE	
1 - OPN./MAINT. SUPT. A	23
2 - PRIN. ENGR. B	21
TURBINE PROPER	
1 - MAINTENANCE HEAD A	18
7 - SR. PLANT MECHANIC	14
4 - PLANT MECHANIC A	12
TURBINE ACCESS./GAS TURBINE	
2 - MAINTENANCE HEAD A	18
10 - SR. PLANT MECHANIC	14
5 - PLANT MECHANIC A	12
AUXILIARY	
1 - OPN./MAINT. SUPT. A	23
3 - PRIN. ENGR. B	21
ROTATING MACHINE	
2 - MAINTENANCE HEAD A	18
8 - SR. PLANT MECHANIC	14
5 - PLANT MECHANIC A	12
1 - PLANT MECHANIC C	8
STATIONARY EQUIPMENT	
1 - MAINTENANCE HEAD A	18
9 - SR. PLANT MECHANIC	14
5 - PLANT MECHANIC A	12
AIR HEATER PIPELINE	
1 - MAINTENANCE HEAD A	18
4 - SR. PLANT MECHANIC	14
3 - PLANT MECHANIC A	12
SOUBA DIVING TEAM	
10 - PLANT MECHANIC A (SOUBA DIVER)	12

51

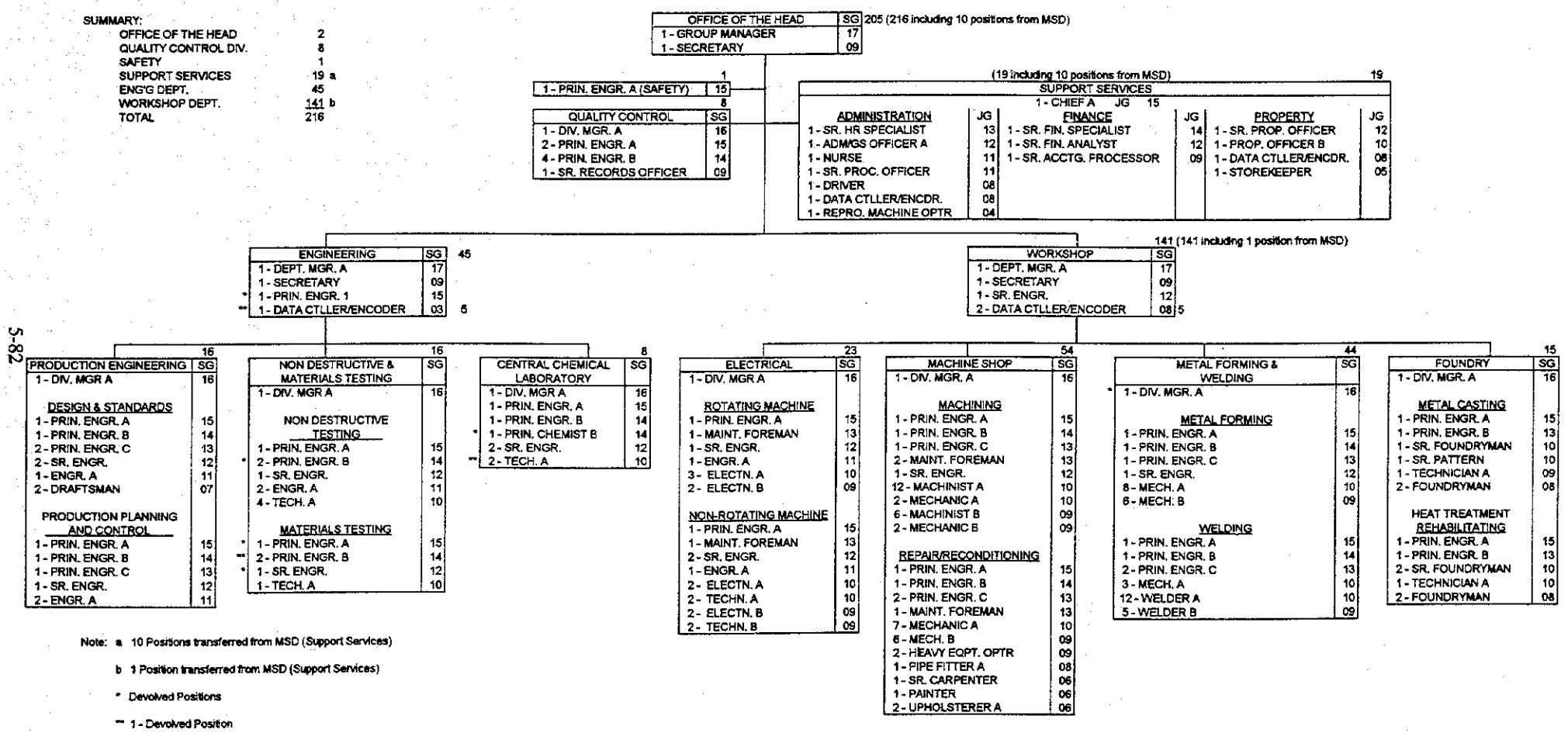
ELECTRICAL	SG
1 - DEPT. MANAGER B	25
1 - ADM. SVCS. ASST. A	12
GENERATOR SVCS.	
1 - OPN./MAINT. SUPT. A	23
1 - PRINCIPAL ENGINEER B	21
2 - MAINTENANCE HEAD A	18
4 - SR. PLANT ELECTRICIAN	14
2 - SR. PLANT MECHANIC	14
2 - PLANT ELECTRICIAN A	12
1 - PLANT MECHANIC A	12
SUBSTATION	
1 - OPN./MANT. SUPT. A	23
2 - PRINCIPAL ENGINER B	21
2 - MAINTENANCE HEAD A	18
4 - SR. PLANT ELECTRICIAN	14
4 - SR. PLANT MECHANIC	14
RELAY SVCS.	
1 - OPN./MAINT. SUPT. A	23
2 - PRINCIPAL ENGINEER B	21
2 - PRINCIPAL ENGINEER C	20
6 - SR. PLANT ELECTRICIAN	14
TEST/METER SVCS.	
1 - OPN./MAINT. SUPT. A	23
2 - PRINCIPAL ENGINEER B	20
3 - PRINCIPAL ENGINEER C	20
6 - SR. PLANT ELECTRICIAN	14

26

SUPPORT SERVICES	SG
1 - ADM./GS CHIEF A	21
ADMINISTRATION	
1 - ADM./GS OFFICER A	16
2 - IRD/IRM OFFICER A (1-MS, 1-MEC)	15
2 - IRD/IRM ASST. A (1-MS, 1-MEC.)	10
1 - SR. IND'L NURSE (MEC)	14
1 - PLT. MECHANIC B (MS & MEC)	12
1 - SR. DRAFTSMAN (MS)	11
2 - DATA ENCODER - CONTROLLER (1-MS, 1-MEC)	10
1 - HEAVY EQPT. OPTR. (MEC)	9
7 - DRIVER-MECHANIC B (4-MS, 3-MEC)	7
1 - LIAISON AIDE (MS & MEC)	4
FINANCE	
1 - SR. FIN'L PLNG. SPCLST. (MEC)	20
2 - SR. FIN'L PLNG. ANALYST (1-MS, 1-MEC)	15
PROPERTY (MS)	
1 - SR. PROP./SUPPLY OFFCE.	16
1 - PROP./SUPPLY OFFCE. B	12
1 - DATA ENCODER - CONTROLLER	10

NOTE Subject to review by JEC and approval of DEM

Figure 5-12 Organization of Maintenance Engineering Center (MEC)



Note: a 10 Positions transferred from MSD (Support Services)

b 1 Position transferred from MSD (Support Services)

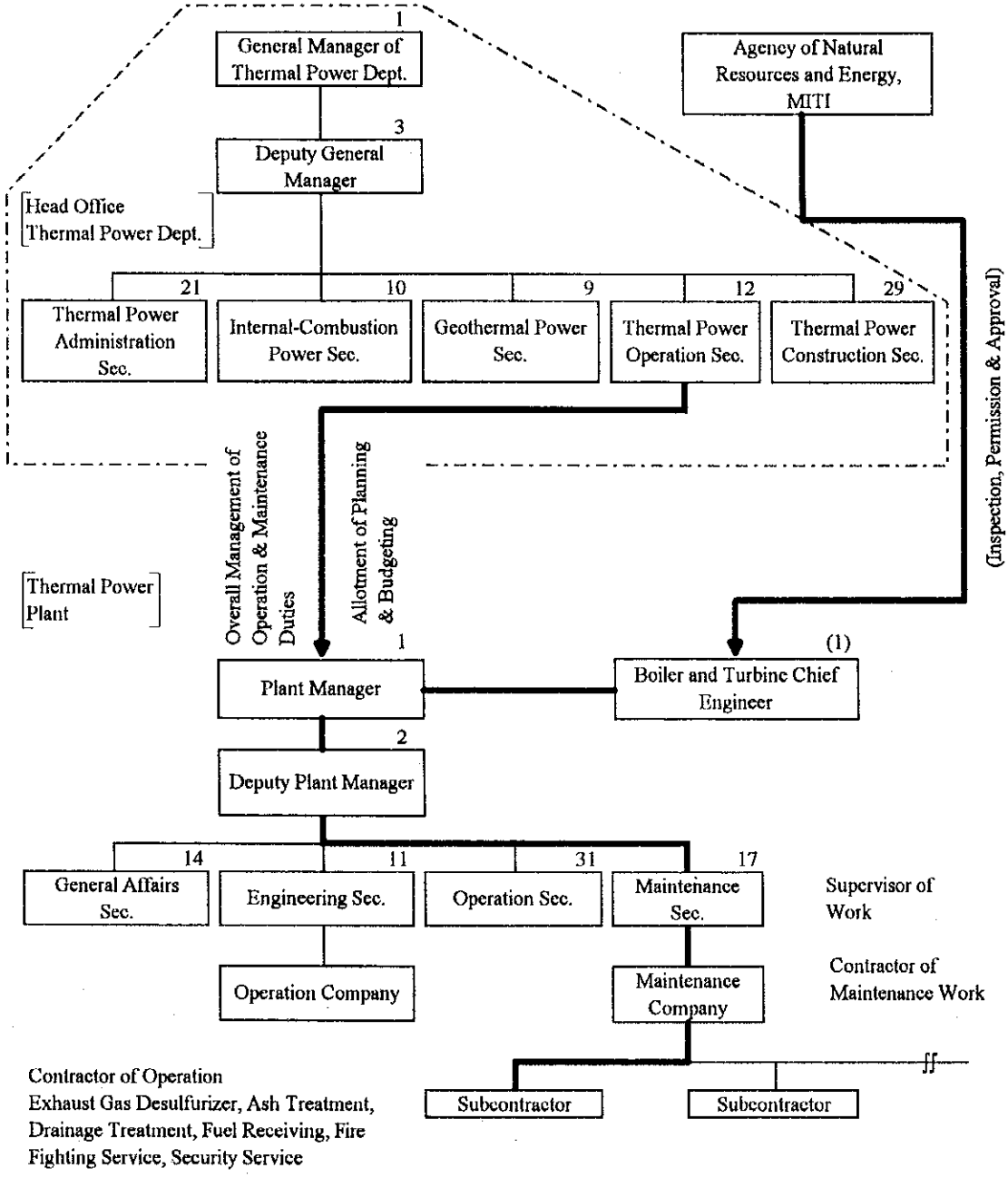
* Devolved Positions

** 1 - Devolved Position

Table 5-28 MSD Man Power List

Activities	Period (Days)	Man Power					
		Foreman	Mechanic	Welder	Electrician	Other	Helpers
Botangas 1 Annual Overhauling 1994							
Retubing of Reheater Outlet Legs	70	2	2	9			20
Retubing of Pry. Superheater Tubes	50		1	9			15
Partial Retubing of Economizer Tubes	55		1	9			15
Repair/Replacement of Coal Burners/ Repacking of Boiler Manholes and Ductings/ Repair of Caster of Burner Studs, Sootblow, Boiler Header, and Air Ports	55		1	3			10
Repair/Replacement of Gas and Air Ducts Expansion Joints, Supports and Insulation	50		1	12		contractor skill 5	20
Inspection/Repair of Dampers, Overhauling Soot Blowers Inspection of Smokestack Lining	65		2	1			10
Hauling/Rigging of Tools and Materials			1				10
Lighting Services and Other Electrical Works					3		
Partial Retubing of Main Steam Condenser Inspection/Repair of Pipe Hanger and Insulation of Cold and Reheat Piping	70		2	1	1		30
Repair/Replacement of MSC Discharge Pipe	51		2	5			8
Overhauling of Circulating Water Pump A, B	36	1		1			8
Inspection/Repair of Fan	66		2				12
Inspection/Repair of Air Heater A, B	66		3	8	1		24
Replacement of Steam Oil Air Heater A Inspection/Repair of Steam Coil Air Heater B	46		1	1			6
Repair/Replacement of Coal Conduits	66		1	2			6
Overhauling of Boiler Feed Pump (M-BFP & T-BFP), Condensate Pump A, B and Heater Drain Pump	66	1	1				8
Overhauling of Steam Pressure CV and Inspection/ Repair of Various Valves	66		1		1		8
Main Turbine Bearing and HP-IP Turbine Coupling Arrangement Check	5	1	3				6
High Pressure Control Valves			2				4
Main Stop Valve and Other Valves			2				4
Malaya 2 Overhauling - 1993							
Replacement of Water Walls RH, Sec. SH, Baffle Walls and Sling Tubes	170		11	30			144
Malaya 1 Overhauling - 1994							
Turbine Bearing Inspection	44	1	4				5
LP-1, LP-2 Turbine Inspection and Re-blading	56	1	4				10
Reassembly of Valves	22	1	5				

Figure 5-13 Organization of the Periodic Maintenance at Power Plant (Japan)



Notes: Figures written at the upper right side of rectangles show number of persons.

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. 5-14)
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 shown in Table 5-29 according to the purchase amount, and process the procurement as described in the following;

Figure 5-14 Purchasing System

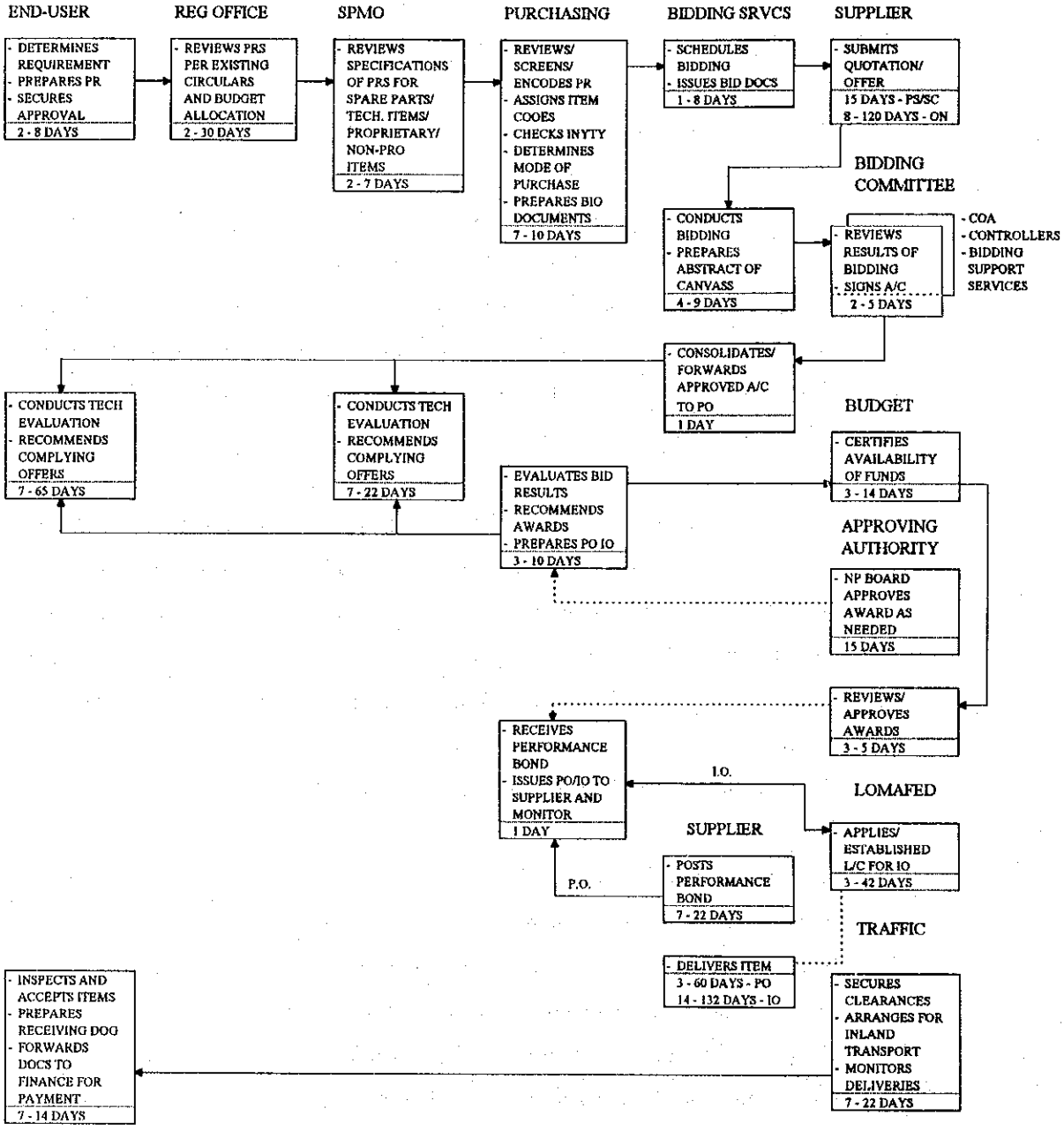


Table 5-29 Manual of Approvals

SUBJECT: MATERIAL MANAGEMENT			
TOPIC: PURCHASE ORDER (PO) AND INDENT ORDERS (IO)			
EFFECTIVE DATE:NOVEMBER 1, 1993			
ITEM	LIMITS OF AUTHORITY		APPROVING AUTHORITY
	PURCHASE ORDER	INDENT ORDER	
1. Fuel Oil for Generating Plants	Regardless of Amount		VP Region
2. Others			
a. Thru Public Bidding	Up to P500T	Up to P1M	Manager, Administration
	Up to P3M	Up to P3M	Resident Manager
	Up to P10M	Up to P10M	VP Region
	Up to P50M	Up to P50M	President
	Over P50M	Over P50M	NP Board
b. Thru Sealed Bidding or Negotiations	Up to P20T	-	Responsibility Center Head Concerned/Sub-Area Manager
	Up to P50T	-	Plant Complex/Plant/Area/Regional Eng'g. Manager/TS*/CM* Manager
	Up to P100T	-	Group Manager Concerned
	Up to P250T	Up to P500T	Manager, Administration
	Up to P1M	Up to P1M	Resident Mgr.
	Up to P5M	Up to P5M	VP Region
	Up to P10M	Up to P10M	President
	Over P10M	Over P10M	NP Board
c. Over the Counter or Telephone Canvass	Up to P5T	-	Plant Complex/Plant/Area/TS/CM Manager/Project Manager (Division Level)
	Up to P10T	-	Manager, Administration/Regional Eng'g./Group Manager Concerned
3. Confirmation PO for Emergency Purchase	Up to P20T	-	Responsibility Center Head Concerned/Sub-Area Manager
	Up to P50T	-	Plant Complex/Plant/Are/TS*/CM* Manager
	Up to P100T	-	Group Manager Concerned
	Over P100T	-	VP-Region
4. Certification of Funds Availability			
a. Fuel Oil and Lube Oil for Generation	Up to P1M	-	Chief, Budget and Financial Analysis
	Over P1M	-	Manager, Finance
b. Others		-	
- Plants/Areas/Field Offices	Up to P20T	-	Sr. Acotg. Processor A
	Up to P100T	-	Sr. Financial Planning Analyst
- Regional Office	Up to P1M	Up to P1M	Chief, Budget and Financial Analysis
	Over P1M	Over P1M	Manager, Finance

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.

NPC has set up the application criteria of the procurement methods as described in the following in accordance with the regulations stipulated in the ANNEX-B of Circular No. 88-34.

- The decision criteria may be applied on a per item basis.
- "Repeat Order" or "Price-Based Order" in accordance with Section 6.3 of this Circular No. 88-34 may be adopted whenever applicable.

  Section 6.3 of Circular No. 88-34

  "In the case of a repeat order for products same as those previously procured by public bidding or sealed canvass in the past six months, procurement may be made from the same supplier under the same terms and conditions of the previous purchase as a rule."
- For spare parts of major equipment and/or existing components thereof which can only be supplied by the original manufacturers or their exclusive distributors, locally or abroad, the mode of procurement shall be Direct Negotiation (DN).
- For those materials, equipment and services which can be supplied by two or more suppliers, follow Table 5-30 for first level action.
- In case of failure of the first level action, follow Table 5-31 for second level action.
- In case of failure of the second level action, negotiate directly with the lowest bidder and if the price/s is not reasonable, negotiate with any of the other bidder or other reputable supplier of the item at the most advantageous price/s, terms and conditions.

Table 5-30 First Level Action

Source	Locally Available			Not Locally Available	
Amount	≤P20T	>P20T			
Date Needed in months (month)		≤3	>3	≤6	>6
Tel. Canvass (TC)	X				
Over the Counter Canvass (OC)	X				
Sealed Canvass (SC)		X		X	
Public Bidding (PB)			X		X

Table 5-31 Second Level Action

Source	Locally Available						Not Locally Available				
Cause of Failure	Only 1 Bidder for PB and less than 3 for SC			No Bidder			Only 1 Bidder for PB and less than 3 for SC			No Bidder	
Remaining Time (month)	≤1	≤3	>3	≤1	≤3	>3	≤3	<5	>5	≤5	>5
Direct Negotiation	X						X				
Sealed Canvass		X			X			X		X	
Public Bidding			X			X			X		X
Over the Counter Canvass				X							

b. Delivery Time

Because of the nature of NPC as a public corporation, the procurement procedures are rather complicated as shown in Figure 5-14 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. The Material Management Department of NPC specifies the standard period required for delivery of goods after the issuance of PR as shown in Table 5-32.

Table 5-32 Standard Period for Delivery of Goods

Procurement Method	Procurement Amount	Domestic Products (days)			Imported Products (days)		
		STD	TECH.	COMP LEX	STD	TECH.	COMP LEX
Public Bidding	<P2M	100	136	190	AR 102 OFE 111 OUS 123 OE 133	180 189 201 211	254 263 275 285
	≥P2M	153	181	235	AR147 OFE 156 OUS 160 OE 170	225 234 246 256	299 308 320 330
Sealed Canvass	<P1M	60	89	146	AR 80 OFE 97 OUS 109 OE 119	163 172 184 194	229 240 260 270
	≥P1M	103	134	191	AR 130 OFE 142 OUS 154 OE 164	208 217 229 239	284 293 305 315
Direct Negotiation	<P1M	76	92	145	AR 87 OFE 96 OUS 108 OE 118	153 162 174 184	221 230 242 252
	≥P1M	121	137	190	AR 132 OFE 141 OUS 153 OE 163	198 207 219 229	266 275 287 297
Direct Negotiation (Repeat Order)	<P1M	44	54	94	AR67 OFE 76 OUS 80 OE 90	127 136 140 150	187 196 200 210
	≥P1M	89	99	139	AR 112 OFE 121 OUS 133 OE 143	172 181 193 203	232 241 253 263

Notes: STD : Standard
TECH : Technical

AR : Air Cargo
OFE : Sea Cargo (Import from Far East)
OUS : Sea Cargo (Import from USA or Canada)
OE : Sea Cargo (Import from Europe)

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

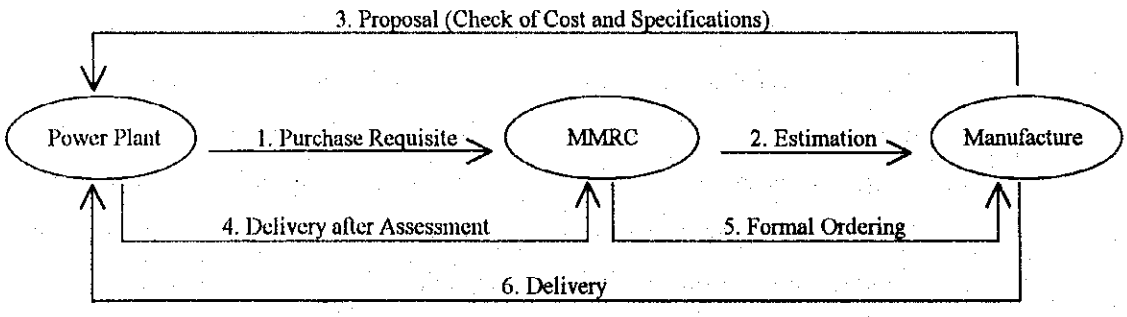
For procurement of spare parts of overhaul and daily maintenance, 3 years procurement plan is prepared by the superintendent of each maintenance group (mechanical, electrical and instrumentation & control maintenance group) based on the results of previous overhauls. It will be submitted to the power 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 inventory 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, pump impellers, etc. and on the basis of the time for delivery as a whole.

Figure 5-15 Ordering Flow



The Purchase Requisite will be issued by the relevant superintendent and elevated to MMRC through the plant manager as shown in the above flow chart.

b. Management of Inventories

Rainwater leak was observed in the large warehouse at Malaya, which might have been caused from the entrance side. Since it may 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.

Items are sorted on racks and tagged. The stock list is controlled with the computer.

The inventories are individually managed by the maintenance groups as classified into mechanical and electrical groups and chemical and instrument groups. The items for make-up of the inventory are being procured through the warehouse.

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

Review of the inventory standard is essential on the basis of the frequency of use, weather worthiness and delivery time of the items.

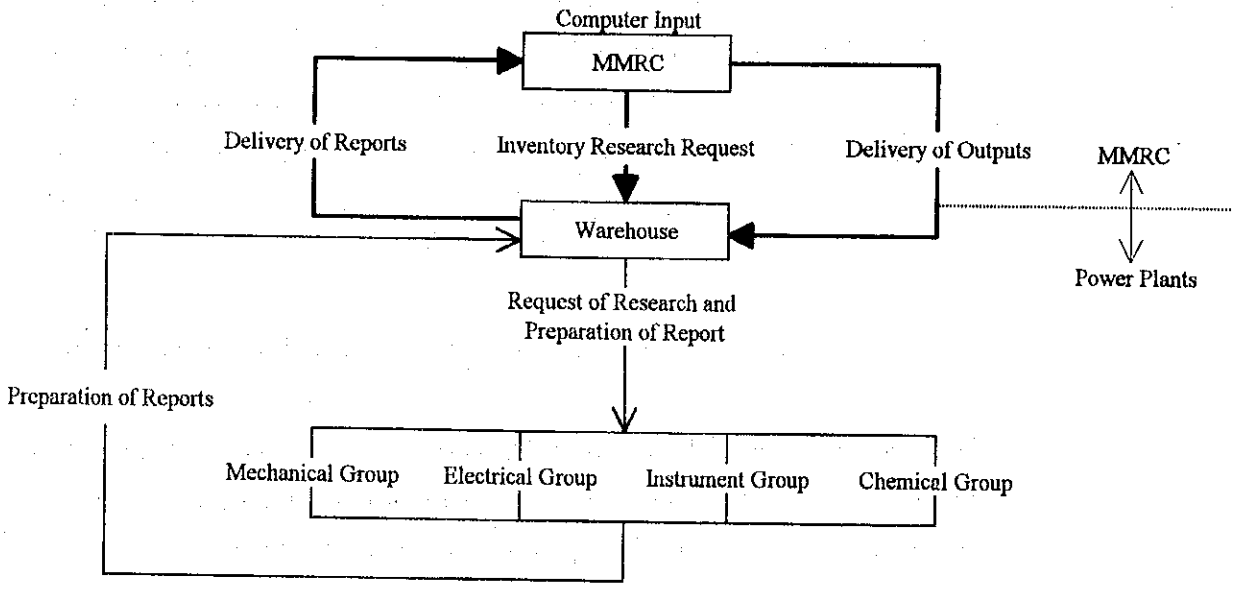
Particularly, quantity of bearings, gaskets, O-rings, etc., can be reduced if order is made according as the overhaul schedule.

c. Inventory Control Organization and System

Mechanical and electrical groups have a common warehouse, and chemical and instrument groups have individual warehouses with independent inventory control. Japanese power plants have almost the same system as Malaya TPP except chemical group which stocks valves, packing rings, etc. in Malaya TPP.

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

Figure 5-16 Inventory Control Structure.



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

Table 5-33 shows the results of hiring from 1989 to 1994 in MMRC. According to this, the number of new employees in 1992 is 11 and that in 1993 is 175, largely fluctuates by years. Table 5-34 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

Table 5-35 shows the personnel filling condition in the Malaya TPP as of July 31, 1994.

- 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.

- Target value of the filling ratio: 85%

As mentioned before, filling the vacancy is DBM and CSC direction. As a result, the filling ratio is normally kept about 85% and generally this is assumed a target value.

- Temporary adoption

Casual personnel may be employed for periodical maintenance as required.

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 5-33 New Employment Record in MMRC

Category		1989				1990				1991				1992				1993				1994			
		NPC as whole	Thermal P.P.	MALAYA	SUCAT	NPC as whole	Thermal P.P.	MALAYA	SUCAT	NPC as whole	Thermal P.P.	MALAYA	SUCAT	NPC as whole	Thermal P.P.	MALAYA	SUCAT	NPC as whole	Thermal P.P.	MALAYA	SUCAT	NPC as whole	Thermal P.P.	MALAYA	SUCAT
Office	CL.										7	1	2						7		1		6	4	4
	H.S.																								
Electrical	CL.		25	11	3		5	4			9	1	7		2		2		46	12	5		6	1	0
	H.S.																								
Mechanical	CL.		36	18	3		5	1			4	1	1		3		3		36	10	7		2	0	0
	H.S.																								
Chemical	CL.		4	1	1						2	1													
	H.S.																								
Civil	CL.						1																		
	H.S.																								
Architectural	CL.																								
	H.S.																								
Other Courses			9	1	1		14	2			17		8		6		5		86	11	8		23	7	0
TOTAL			74	31	8		25	7			39	4	18		11		10		175	33	21		37	12	4

CL.: COLLEGE
H.S.: HIGH SCHOOL

Table 5-34 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)

Table 5-35 Malaya TPP Personnel Filling Condition

As of July 31, 1994

Unit/Section	Authorized Position	Permanent	Temporary	Total	Total Vacancies
Office of the Plant Manager	2 (2)	2	-	2	-
Efficiency Control	8 (8)	8	-	8	-
Support Services	20 (18)	16	1	17	3 (1)
Office of Operation Manager	2 (2)	2	-	2	-
Chemical	22 (22)	17	-	17	5 (5)
Operations, G.T. S/S	23 (23)	19	-	19	4 (4)
Operations, Thermal	*114 (114)	82	19	101	13 (13)
Office of Maintenance Manager	2 (2)	1	-	1	1 (1)
Planning & Scheduling	7 (7)	6	-	6	1 (1)
Mechanical	44 (44)	41	2	43	1 (1)
Electrical	21 (21)	17	2	19	2 (2)
Instrument & Control	15 (15)	11	2	13	2 (2)
General Services	16 (16)	11	-	11	5 (5)
Total	296 (294)	233	26	259	37 (35)

Note: *1 ( ) show numbers indicated in the chart of organization structure.

*2 Including personnel in charge of fuel

b. Problems Related to Personnel Recruitment

a) Recruitment Policy and Plan

- DBM direction of filling the vacancy is logically correct to keep the number of authorized position constant, but actually it seems that the number of authorized positions is not full at all.

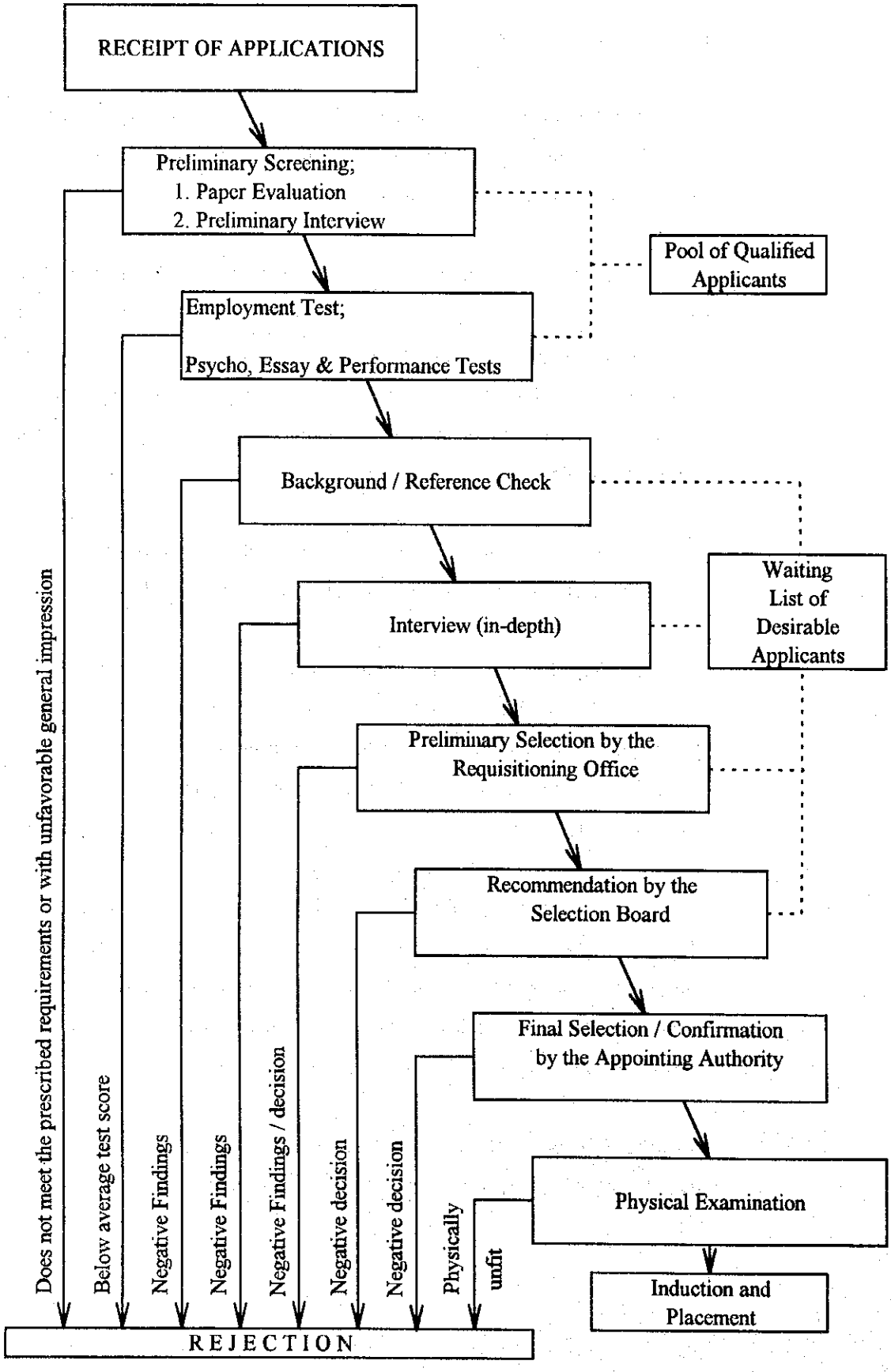
  If the vacancy could not be filled up, the filling ratio will continue to be less than 90% as shown in the present personnel condition of the Malaya TPP of Table 5-35. Some of the concerned say that keeping 85% filling ratio is DBM and CSC directions. Then, the number of authorized positions should be 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. To provide effective and unified education and training for On-the-Job Training (OJT), as well as for group education, the number of trainees for each education course will be limited considering facilities, trainers, and teaching materials.

  It is, therefore, necessary to formulate a long term employment plan to unify the number of new employees per year as much as possible.

Figure 5-17 Flow Chart of Selection Procedure



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.

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 for OJT to each position in the power plant without undergoing such training.

b) Current Education and Training of Newly Recruited Operators in the Power Plant

Outline of education and training for newly recruited employees (hereinafter, referred to as training) is as follows:

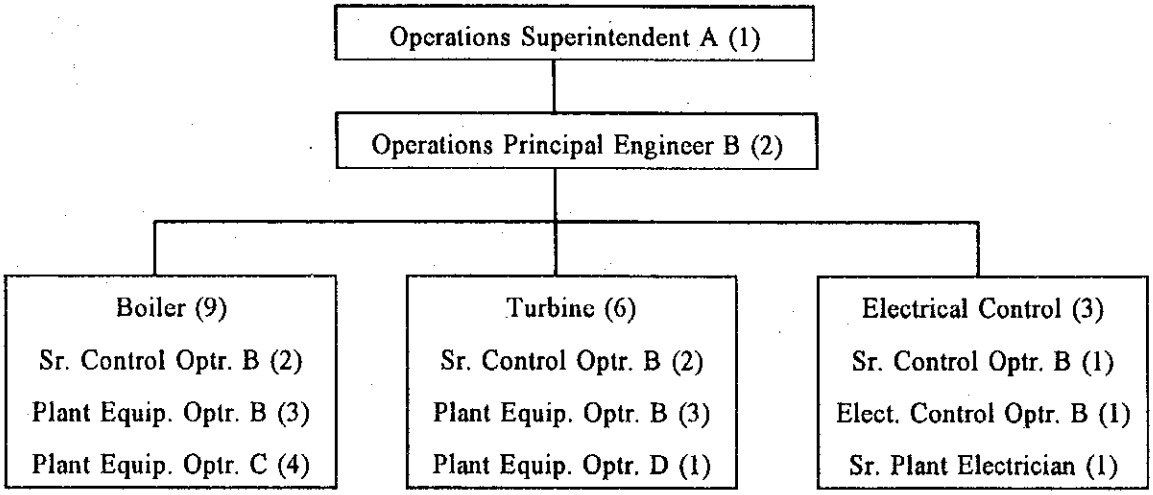
Responsible person:	Superintendent A and principal engineer B of shift operations
Trainer:	Sr. Control operator and plant equipment operator of facilities (boiler, turbine, electrical/control)
Trainee:	Newly recruited employees (neither trained as an operator nor has experience of operations)
Position to be trained:	Auxiliary machine operator Newly recruited employees start training for his position.
Training method:	OJT
Training period:	Normally 2~3 months

c) Position Training of Operators

According to the organization table of the power plant mentioned in the Figure 5-5, each operation shift must be organized with the number of staffs as shown in Figure 5-18. But the assignment of the actual operators follows Figure 5-19 according to the Table 5-1.

Figure 5-18 Shift Operations; Organization (Official Complement)

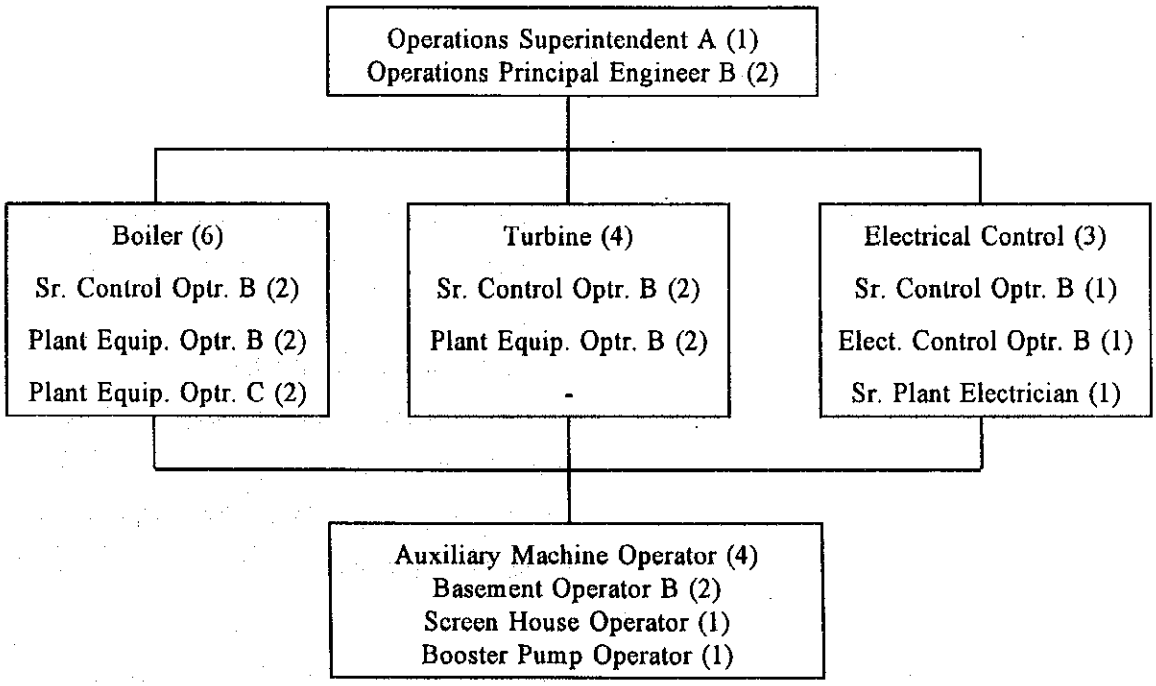
Total 21 persons



Note: Figures in the parenthesis ( ) indicate the number of personnel of one operation shift for two power generating units. Part of the personnel assigned to chemical services also work in shifts, though they are not described in the above table.

Figure 5-19 Shift Operations; Organization (Actual)

Total 20 persons



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 four requirements of the present Qualification Standards (QS). (See Table 5-36.) 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.

Outline of Position Training of Operators

Responsible person:	Operations Manager & Operations Superintendent A		
Trainer :	Superintendent A and Operation Principle Engineer B of Operations		
Trainee :	Appointed operators	Persons who apply position training (boiler, turbine, or electrical control operator)	
Position to be trained:	Position to be filled	Applied position	
Training method :	OJT		
Training period :	- If a trainee has no operation experience, he has to undergo one to two years training based on the QS. - If a trainee has sufficient relevant experience, at least four to eight hours training is required to satisfy the training requirements in the QS. - Trainees must pass evaluation and judgment by a responsible person.		

Table 5-36 Qualification Standards on Plant Operation (Abstract)

Position Title		Requirements			
		Education	Experience	Training	Eligibility
Operation/Maintenance Superintendent A [23]		BD * relevant to the job	4 years in position involving M&S	24 Hrs. in M&S	CS (professional): AE for 2nd. level position
Principal Engineer B [21]		Ditto TR course	3 years relevant experience (Rel. Exp.)	16 Hrs. of relevant training (Rel. T.)	RA 1080
Senior Control Operator B [17]		Completion of 2 years studies in CO, VO or TR course	2 years Rel. Exp.	8 Hrs. of Rel. T.	CS (sub-professional). AE for 1st. level position
Plant Equip. Operator B [14]		HS: completion of relevant VO. or TR course	2 years Rel. Exp.	Ditto	Plant Equip. Operator
Electrical Control Operator B [14]		Completion of 2 years studies in CO.	1 year Rel. Exp.	4 Hrs. of Rel. T.	CS (sub-professional) AE for 1st. level position
Plant Equip. Operator C [12]		HS. Completion of relevant VO, or TR course	1 year Rel. Exp.	4 Hrs. of Rel. T.	Plant Equip. Operator
Senior Plant Electrician [14]		Completion of 2 years studies in CO.	Ditto	Ditto	RA 1080
Auxiliary Machine Operator	IV [11]	HS: Completion of rel. VO, or TR course	2 years Rel. Exp.	8 Hrs. of Rel. T.	Aux. Machine Operator
	III [08]		1 year Rel. Exp.	4 Hrs. of Rel. T.	
	II [06] I [04]		None required	None required	

Note: Figures in the square brackets indicate Salary Grade (SG).

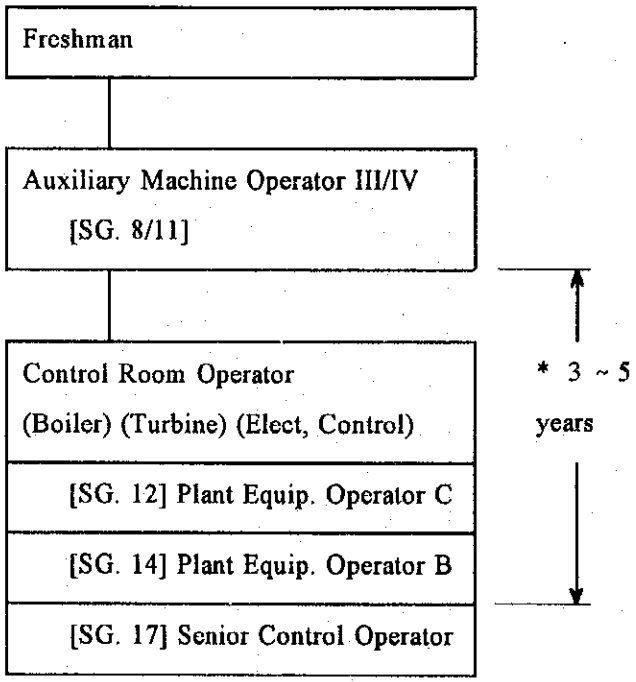
* Effective: Jan. 1, 1995

BD = Bachelor's degree
CO = College
VO = Vocational School
TR = Trade Course
HS = High School Graduate
M&S = Management and Supervision
Rel. Exp. = Relevant Experience
Rel. T. = Relevant Training
CS = Career Service
AE = Appropriate Eligibility

Promotion and Number of Experience Years of Operators

Operators learn their positions in the following steps and promote as shown in Figure 5-20:

Figure 5-20 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. Table 5-37 shows experience years of operators at present.

Table 5-37 Experience Years of Operators

Job Position	Number	Familiarity with Boiler, Turbine, Electrical & Control					Experience Years in Present Job			
		Boiler	Turbine	E & C	Double	Triple	<3	<6	<10	>10
Operations Superintendent A	5					5		1		4
Operations Principal Engineer B	10					10	1	5		4
Boiler										
Sr. Control Operator B	10	10					1	2	3	4
Plant Equipment Operator B	10	10					3	3	2	2
Plant Equipment Operator C	9	9					9			
Turbine										
Sr. Control Operator B	9		8			1	1	1	1	6
Plant Equipment Operator B	10		10				3	3	4	
Electrical Control (Switchboard)										
Sr. Control Operator B	5			5			1			4
Electrical Control Operator B	5			5			1	4		
Sr. Plant Electrician	5			5			1		1	3
Auxiliaries										
Basement Operator B	10				10		2	4	2	2
Screen House Operator	4		4				4			
Booster Pump Operator	5	5					5			
Subtotal	97 100.0%	34 35.1%	22 22.7%	15 15.5%	10 10.3%	16 16.5%	32 33.0%	23 23.7%	13 13.4%	29 29.9%
Chemical Service										
Principal Chemical Engineer C	4						2			2
Plant Equipment Operator B	11						1	4		6
Subtotal	15 100.0%						3 20.0%	4 26.7%		8 53.3%
Total	112 100.0%						35 31.3%	27 24.1%	13 11.6%	37 33.0%

d) Characteristics of the Operations Division

Career record of operators

- Of operators, 30% came from MERALCO and have been working in the Malaya TPP for 20 years. (The Malaya TPP was transferred from MERALCO to NPC in 1978.)

- Once, they were recruited as operators, most of them work in the same power plant as operators until their retirement.

- Few operators move to the other sections from the shift operations in the same power plant. Only about 8 people moved to the other sections within the Malaya TPP since the commissioning of Malaya TPP. And, few people moved to the other power plant or MMRC from Malaya TPP. Thus the position training has been performed within the Operations division only. As a result, the shift operations are provided with the following characteristics:
  - All of the Operations Superintendents and the Operations Principal Engineers master three positions of boiler, turbine and electrical/control
  - Of Senior Control Operators, 30% have learned both boiler and turbine positions. But according to Table 5-37, only one Senior Control Operator mastered both the boiler and turbine positions.
  - Few operators below Senior Control Operators have learned multiple positions.
  - Promotion depends on an opportunity of shifting due to occurrence of a vacancy. This makes operators stay long in the same position.
  - Promotion depends on an operator's academic background. The college graduate generally promotes faster than the vocational school graduate.

b. Problems of Operators Training and Its Solution

a) No 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 revising action and implementation plan.

The present agenda to be studied is as follows:

The new employees recruited by MMRC will 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 5-38 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 only 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 some training programs for operators already exist, the 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

"To eliminate forced outage between two adjacent periodic overhauls, i.e., after the periodic overhaul of this time until the periodic overhaul of next time, at the power plant" was indicated by JICA as the target of the software improvement study.

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 operators' skills 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 started in Bataan TPP. The same 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

Training using an operation simulator:

An operation simulator will be installed at the Batangas TPP as a part of the No. 2 unit construction project. It is necessary to start preparation of an operator training plan to be implemented using the operation simulator to be installed at the Batangas TPP.

Evaluation of skill and experience of operators:

The Human Resources Department of NPC is now preparing an action plan, in coordination with the Regional Centers, for enhancement and evaluation of skill of plant operators including operators at thermal power plants.

According to this action plan, it appears that accrediting examination for evaluation of the result of training will be conducted for each operator grade level.

NPC's action plan for operator training

Objective: "To train operators to such a skill level that is anticipated to minimize operator errors"

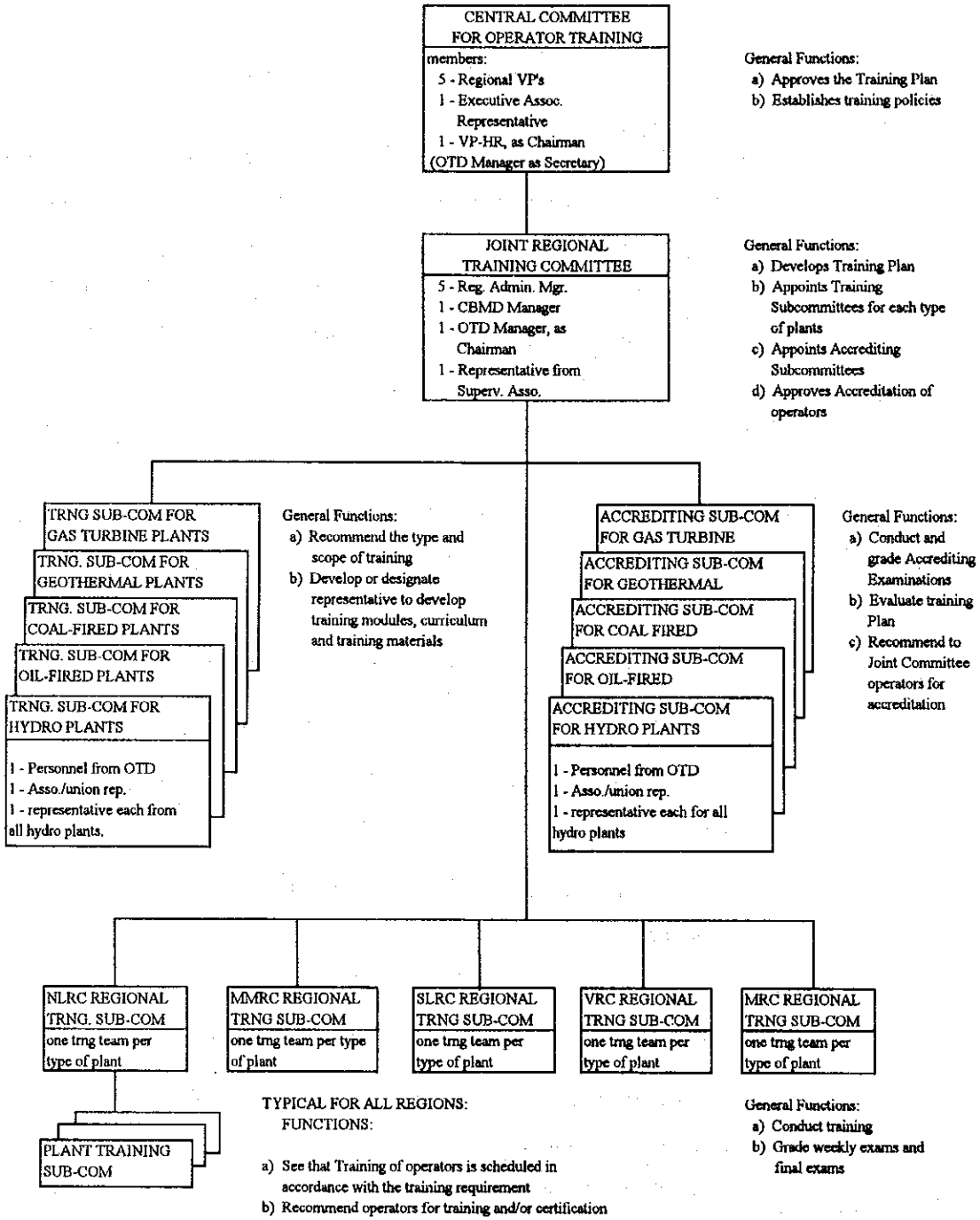
Method: The qualification, training and experience of each operator will be reviewed through job audit. One action plan will be developed to identify incompleteness. The vice president of Human Resources Department will develop a certification program for control room operators in coordination with the vice president of the Regional Center.

Structure: See Figure 5-21.

Major functions and assignments of the operator training program given in the Figure 5-21 are as follows.

Function	In-charge
- Develops Training Plan	Joint Regional Training Committee
- Recommends type and scope of training, etc.	Training Sub-Committee
- Conducts and grades Accrediting Examinations, etc.	Accrediting Sub-Committee
- Conducts training, Grade weekly exams and final exams.	MMRC Regional Training Sub-Committee
- To see that training of operators is scheduled according to the requirement and recommends operators for training and/or certification	Plant Training Sub-Committee

Figure 5-21 Operator's Training Plan



Case of Japan

General principles of operator training in Japan are shown in Table 5-39.

The points of these principles 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 (see Table 5-40.).

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.

Table 5-39 Comparison of General Principles of Operator Training

Freshman Training (1st stage)	Fundamental technology training (2nd stage)		Expert technology training (3rd stage)
(NPC) - OJT (On-the Job-Training) - No collective training	- OJT - Collective training - Basic Thermal Power Plant operation course for Rank-and-File. - Refresher course on Thermal Power Plant operation for Supervisory level and Rank-and-File.		- OJT - Collective training Review course on Thermal Power Plant operation for Supervisory level.
(Case of Japan) - Collective training at staff training center . . . 3 months - Apprentice training at thermal power plants . . . 6 months	Position training at thermal power plants - 2nd ~ 3rd years after entry to the company - To learn all positions of boiler, turbine and electrical control	- Thermal power plant operation simulator training at staff training center (with focus on start and stop) - Thermal power plant fundamental skill training at staff training center All of engineering staff of the third year after entry to the company . . . 5 days - Thermal power plant maintenance technology training at staff training center Seasoned operators of Shift Operations Section . . . 5 days	- Thermal power plant operation simulator training at staff training center (with focus on trouble shooting training) - Thermal power plant maintenance technology training at staff training center Senior operators of Shift Operations Section . . . 5 days

Table 5-40 Simulator Training for Operators (Case of Japan)

Course	Contents of Training	Object/Purpose	Training Period
A Fundamental Course	- Unit start-up / shutdown operation - Routine operation	Operators of second year after entry to the company. Learning of knowledge on plants and of practice of running as well as uplift of consciousness	5 days
B Senior operator course	- Trouble shooting operation - Special running operation	Those who finished fundamental course Upbringing of running operation technology and of total judging capabilities	3 days
C Workshop course	- Unit start-up / shutdown operation - Trouble shooting operation - Themes requested by the power plant	Operators (of the same workshop and team) Upbringing of teamwork and enhancement of technology	3 days
D Leader course	- Learning of objectives of training courses, training manuals and training technology - Handling of simulator equipment and functions	Those who finished courses A and B Upbringing of instructors to establish the pre-learning structure of trainees	4 days
Self-initiated training	- Unit start-up / shutdown operation - Trouble shooting operation	Trainees	2 days

c. Current Situations of Maintenance Division

a) Freshman Collective Training

No collective training, but only OJT, is conducted like the case of operators.

b) Training of Newly Employed Maintenance Staff at the Power Plant

Training of newly employed maintenance staff

Responsible person:	Superintendent of each maintenance group (Mechanical, Electrical, Instrument/Control and General Services)
Trainer:	Principal Engineer B of each maintenance group and Mech. or Elect. Maintenance Head, or Senior Plant mechanic of Electrician
Trainer:	Newly employed maintenance staff
Position to learn:	Position the trainer is in charge
Learning Method:	On-the-job training
Learning Period:	1 ~ 2 years (relevant experience period for taking the subject position specified in QS)

c) 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) as shown in Table 5-41. 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.

Table 5-41 Qualification Standards on Maintenance at Malaya TPP

Position Title	Requirements			
	Education	Experience	Training	Eligibility
Common to all groups -Operation/ Maintenance Superintendent A [23]	BD* relevant to the job	4 years in position including M & S	24 Hrs. in M & S	CS (professional): AE for 2nd level position
Common to all groups -Principal Engineer B [21]	BD* in Engineering relevant to the job	3 years Rel. Exp.	16 Hrs. of Rel. T.	RA 1080
-Mech. Maintenance Head A [18]				
-Sr. Plant Mechanic [14]	Completion of 2 years studies in CO.	1 year Rel. Exp.	4 Hrs. Rel. T.	RA 1080
-Plant Mechanic A [12]	HS graduate: completion 4 Rel. VO. TR.	2 years Rel. Exp.	8 Hrs. Rel. T.	Mechanic
(Electrical Maintenance) -Elect. Maintenance Head A [18]				
-Sr. Plant Electrician [14]	Completion of 2 years studies in CO	1 year Rel. Exp.	4 Hrs. Rel. T.	RA 1080
-Plant Electrician A [12]	HS graduate completion of Rel. VO. TR.	2 years Rel. Exp.	8 Hrs Rel. T.	Electrician
-Ditto B [10]	Ditto	1 year Rel. Exp.	4 Hrs. Rel. T.	Ditto
(Inst. & Control) -Principal Engineer B [20]	BD* in Engineering Rel. to the job	2 years Rel. Exp.	8 Hrs. Rel. T.	RA 1080
(General Services) -Adm./GS Officer A [16]	BD Rel. to the job	2 years Rel. Exp.	8 Hrs. Rel. T.	CS (professional) AE for 2nd level position
-Senior Insulation Man [9]				

Position Title	Requirement			
	Education	Experience	Training	Eligibility
-Heavy Equip. Operator [6]	HS: Completion of Rel. VO. TR Course	Not required	Not required	Heavy equip. operator
-Supervising Carpenter [9]	HS.	2 years Rel. Exp.	8 Hrs. Rel. T.	Carpenter
-Pipe fitter [8]				
-Supervising Painter [9]	HS.	2 years Rel. Exp.	8 Hrs. Rel. T.	Painter

* Effective: Jan. 1, 1995

Note: Inside of [ ] indicates SG, that is, salary grade.

BD = Bachelor's degree

CO = College

VO = Vocational School

TR = Trade Course

HS = High School Graduate

Rel. = Relevant

M & S = Management and Supervision

Rel. Exp. = Relevant Experience

Rel. T. = Relevant Training

CS = Career Service

AE = Appropriate Eligibility

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 5-42 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:
- Lack of collective training, job rotation and position rotation
- Position training of operators should be regularly conducted.
- An operation simulator is required.
- Improvement of ethics