CHAPTER 4

RELIABILITY IMPROVEMENT PLAN OF HARDWARE

CHAPTER 4 RELIABILITY IMPROVEMENT PLAN OF HARDWARE

4.1 Outline of Malaya Thermal Power Plant

The Malaya TPP is located along the eastern shore of the Laguna Lake at Bario Malaya of Pililia, Rizal Province, roughly 70 km southeast of Metro Manila. The Malaya TPP has 740 MW capacity in total consisting of two (2) oil-fired thermal power units, Unit No.1 of 300 MW and Unit No.2 of 350 MW rated capacity, and three (3) gas turbine units with 30 MW rated capacity each. The two (2) oil-fired thermal units are the objective units for the study, and the outlines of the units are introduced in the following sub-sections.

4.1.1 Outline of Facilities

The technical specifications of the major facilities of the Malaya Units No.1 and No.2 are summarize as follows.

1) Malaya Unit No.1

a. Boiler

Type	Once-through Benson Boiler
Maximum Evaporation	1,033.7 tons/hr.
Steam Pressure (SH Out/RH Out)	194.8 kg/cm^{2}g / 38.3 kg/cm^{2}g
Steam Temperature (SH Out/RH Out)	541 °C / 541 °C
Fuel	Residual Oil Bunker C
Manufacturer	Babcock Hitachi K.K.

b. Turbine

Type	Tandem-compound, Single Reheat Extraction, Condensing
Rated Output	300,000 kW
Steam Pressure	189.8 kg/cm^2g
Steam Temperature (Main Steam/Hot Reheat)	538 °C/ 538 °C
Exhaust Vacuum	709.2 mmHg
Speed	3,600 rpm
Manufacturer	Siemens A.G.

c. Generator

Type	Totally Enclosed, Hydrogen Cooled
Rated Capacity	370,000 kVA (45 $psigH_2$)
Rated Voltage	21,000 V
Frequency	60 Hz
Power Factor	0.9
Manufacturer	Siemens A.G.

d. Main Transformer

Type	AFOC-3AMN/Y5CP, Oil Immersed, (FOA) Auto Transformer, Outdoor Type
Capacity	370,000 kVA
Primary Voltage	21 kV
Secondary Voltage (HV/LV)	230 kV/117.3 kV
Phase	3 phase
Connection	Delta-WYE/WYE
Neutral (HV side)	Solidly Grounded
Cooling System	Forced Oil, Forced Air Cooled (FOA)
Manufacturer	Hitachi Ltd.

2) Malaya Unit No.2

a. Boiler

Type	Single Drum, El Paso, Radiant, Indoor Type
Maximum Evaporation	1,305.4 tons/hr.
Steam Pressure (SH Out/RH Out)	173.8 kg/cm^2g / 32.7 kg/cm^2g
Steam Temperature (SH Out/RH Out)	541 °C/541 °C
Fuel	Residual Oil Bunker C
Manufacturer	Babcock Hitachi K.K.

b. Turbine

Type	Tandem-compound, Reheat, Four Flow, Extraction, Condensing, TC4F-26
Rated Output	350,000 kW
Steam Pressure	168.7 kg/cm^{2}g
Steam Temperature (Main Steam/RH Steam)	538 °C/538 °C
Exhaust Vacuum	699.1 mmHg
Speed	3,600 rpm
Manufacturer	Hitachi Ltd.

c. Generator

Type	Totally Enclosed, Hydrogen Cooled, Hitachi Type Form TFLQQ-KD
Rated Capacity	438,000 kVA
Rated Voltage	21,000 V
Frequency	60 Hz
Power Factor	0.9
Manufacturer	Hitachi Ltd.

d. Main Transformer

Type	AFOC-3MN/Y5CP, Oil Immersed (FOA), Auto Transformer, Outdoor Type
Capacity	442,000 kVA
Primary Voltage	21 kV
Secondary Voltage (HV/LV)	230 kV/117.3 kV
Phase	3 phase
Connection	Delta-WYE/WYE
Neutral	Solidly Grounded
Cooling System	Forced Oil, Forced Air Cooled (FOA)
Manufacturer	Hitachi Ltd.

4.1.2 Operational Data

Malaya Unit No.1 was initially synchronized on December 20, 1974 and commenced the commercial operation from August 15, 1975. As of August 25, 1994, the total operating hours reached 119,789.93 hours (69.4% of the total period hours) since the initial synchronization, and the total outage hours, 52,726.22 hours (30.6%). The total number of star-up and shutdown in the same period is 364 times. Refer to Tables 4-1 and 4-5.

Malaya Unit No.2 was initially synchronized on March 10, 1979 and commenced the commercial operation from April 21, 1979. As of August 25, 1994, the total operating hours reached 104,162.91 hours (76.9% of the total period of hours) since the initial synchronization, and the total outage hours, 31,362.82 hours (23.1%). The total number of start-up and shutdown in the same period is 206 times. Refer to Tables 4-2 and 4-5.

During the 1980's, the performance of both the units had declined. The derated unit capacities and insufficient reliability resulted in a low capacity factor and decrease of power generation. Both the units were rehabilitated in 1986 for Unit No.2 and in 1987 in Unit No.1, and the performance was recovered.

The operating data of both the units after the rehabilitation are summarized in the Tables 4-3 and 4-4. Both the units had been operated with good performance for around 4 ~ 5 years after the rehabilitation. But the performance has again been declining year by year at five (5) years after the rehabilitation due to insufficient maintenance. Figures 4-1, 4-2, 4-3, 4-4, and 4-5 show the recovered and declining operating conditions after the rehabilitation on total power generation, capacity factors, operating and outage hours and average load.

These operating data explain that the power plant performance can be recovered and maintained with a proper maintenance but the performance declines easily due to insufficient maintenance efforts, or the proper management of operation and maintenance is important and indispensable for maintaining performance and reliability of the power plant.

Table 4-1 Operating Hours Malaya Unit No.1

Year	Operating Hours	Outage Hours	Period Hours
1974	35.98	244.17	280.15
1975	2,454.01	6,305.99	8,760.00
1976	6,338.14	2,445.86	8,784.00
1977	7,499.04	1,260.96	8,760.00
1978	7,764.46	995.54	8,760.00
1979	7,713.12	1,046.88	8,760.00
1980	4,546.26	4,237.74	8,784.00
1981	7,696.58	1,063.42	8,760.00
1982	6,876.75	1,883.25	8,760.00
1983	5,383.24	3,376.76	8,760.00
1984	5,412.61	3,371.39	8,784.00
1985	5,227.35	3,532.65	8,760.00
1986	6,039.11	2,720.89	8,760.00
1987	2,332.80	6,427.20	8,760.00
1988	7,510.51	1,273.49	8,784.00
1989	6,249.25	2,510.75	8,760.00
1990	7,781.12	978.88	8,760.00
1991	6,492.57	2,267.43	8,760.00
1992	5,932.29	2,851.71	9,784.00
1993	6,709.63	2,050.37	8,760.00
'94/Jan. 1 ~ Aug. 25	3,795.11	1,880.89	5,676.00
Total	119,789.93 (69.4%)	52,726.22 (30.6%)	172,516.15

Table 4-2 Operating Hours Malaya Unit No.2

Year	Operating Hours	Outage Hours	Period Hours
1979	5,873.72	1,239.01	7,112.73
1980	6,158.81	2,625.19	8,784.00
1981	7,439.19	1,320.81	8,760.00
1982	6,505.49	2,254.51	8,760.00
1983	7,100.49	1,659.51	8,760.00
1984	7,991.54	792.46	8,784.00
1985	6,352.48	2,407.52	8,760.00
1986	5,464.71	3,295.29	8,760.00
1987	7,657.61	1,102.39	8,760.00
1988	7,368.85	1,415.15	8,784.00
1989	8,039.75	720.25	8,760.00
1990	7,483.95	1,276.05	8,760.00
1991	6,663.32	2,096.68	8,760.00
1992	8,073.63	710.37	8,784.00
1993	3,401.08	5,358.92	8,760.00
'94 Jan. 1 ~ Aug. 25	2,588.29	3,087.71	5,676.00
Total	104,162.91 (76.9%)	31,361.82 (23.1%)	135,524.73

Table 4-3 Malaya Unit No.1 Operating Data after Rehabilitation

(As of August 25, 1994)

		1987	1988	1989	1990	1991	1992	1993	1994
Rated Output	(MW)	300	300	300	300	300	300	300	300
Average Load	(MW)	245	251	250	268	243	209	177	84
Power Generation	(GWh)	538.00	1,884.00	1,567.67	2,106.03	1,581.82	1,245.69	1,159.04	329.94
Service Hours	(hr.)	2,194.42	7,495.65	6,265.34	7,863.42	6,521.29	5,949.17	6,553.64	3,939.46
Outage Hours	(hr.)	6,565.58	1,288.35	2,494.66	896.58	2,238.71	2,834.83	2,206.36	1,895.54
-Planned Outage	(hr.)	6,374.65	966.12	0.00	212.75	837.73	1,216.97	0.00	0.00
-Non-planned Outage	(hr.)	190.93	322.23	2,429.33	683.83	1,400.98	1,617.86	2,206.36	1,895.54
-Outside Accident	(hr.)	0.00	0.00	65.33	0.00	0.00	0.00	0.00	0.00
Capacity Factor	(%)	20.47	71.49	59.65	80.14	60.19	47.27	44.10	18.86
Heat Rate	(BTU/kWh)	10,458	10,256	10,431	10,883	10,934	11,494	11,575	16,787
Efficiency	(%)	32.63	33.27	32.71	31.35	31.21	29.69	29.48	20.33
No. of Start-up/Shutdown		13	15	22	19	15	19	16	9

Table 4-4 Malaya Unit No.2 Operating Data after Rehabilitation

(As of August 25, 1994)

		1987	1988	1989	1990	1991	1992	1993	1994
Rated Output	(MW)	350	350	350	350	350	350	350	350
Average Load	(MW)	254	286	280	292	287	222	131	271
Power Generation	(GWh)	2,028.00	2,121.00	2,209.31	2,197.69	1,897.06	1,828.97	440.50	701.48
Service Hours	(hr.)	7,972.60	7,409.58	7,883.75	7,533.16	6,604.13	8,229.64	3,360.98	2,588.30
Outage Hours	(hr.)	787.40	1,392.82	876.25	1,226.84	2,155.87	554.36	5,399.02	3,243.70
-Planned Outage	(hr.)	0.00	1,093.38	750.97	694.21	1,658.20	0.00	4,524.42	2,113.18
-Non-planned Outage	(hr.)	758.18	270.22	113.85	532.63	497.67	554.36	874.60	1,130.52
-Outside Accident	(hr.)	29.22	29.22	11.43	0.00	0.00	0.00	0.00	0.00
Capacity Factor	(%)	66.14	68.99	72.06	71.68	61.87	59.49	14.37	34.37
Heat Rate	(BTU/kWh)	9,982	9,778	9,909	10,021	9,945	10,554	11,321	11,032
Efficiency	(%)	34.18	34.90	34.43	34.05	34.31	32.33	30.14	30.93
No. of Start-up/Shutdown		11	12	7	10	7	8	9	7

Figure 4-1 Malaya Thermal Power Plant
Power Generation after Rehabilitation

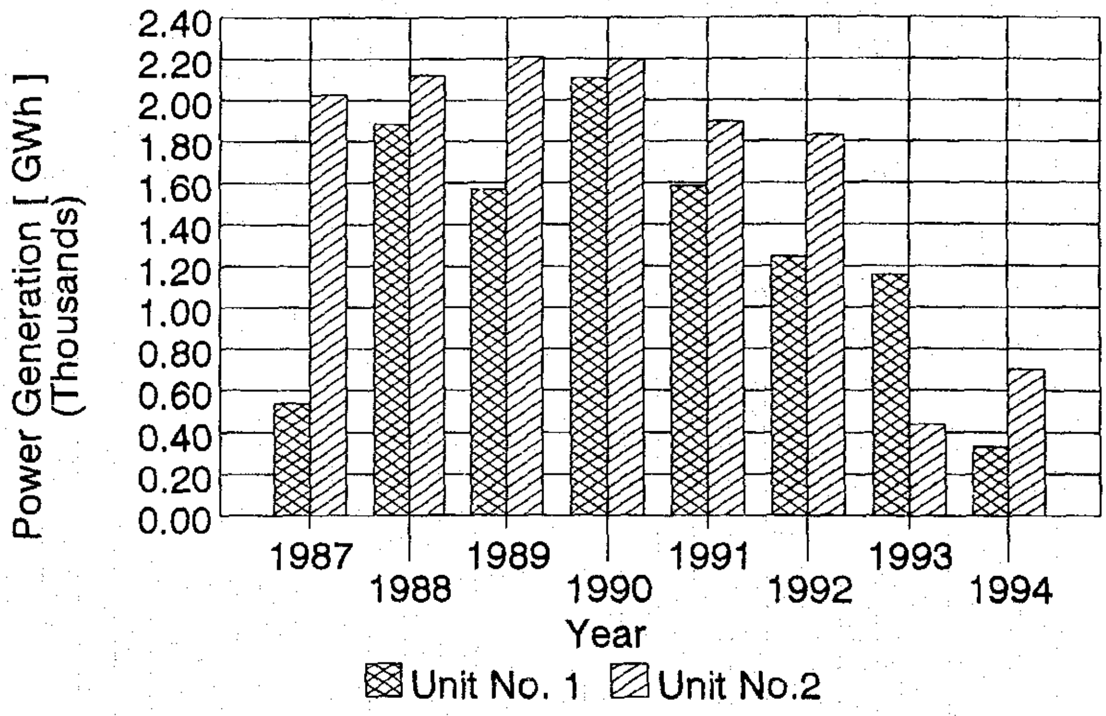


Figure 4-2 Malaya Thermal Power Plant
Capacity Factor after Rehabilitation

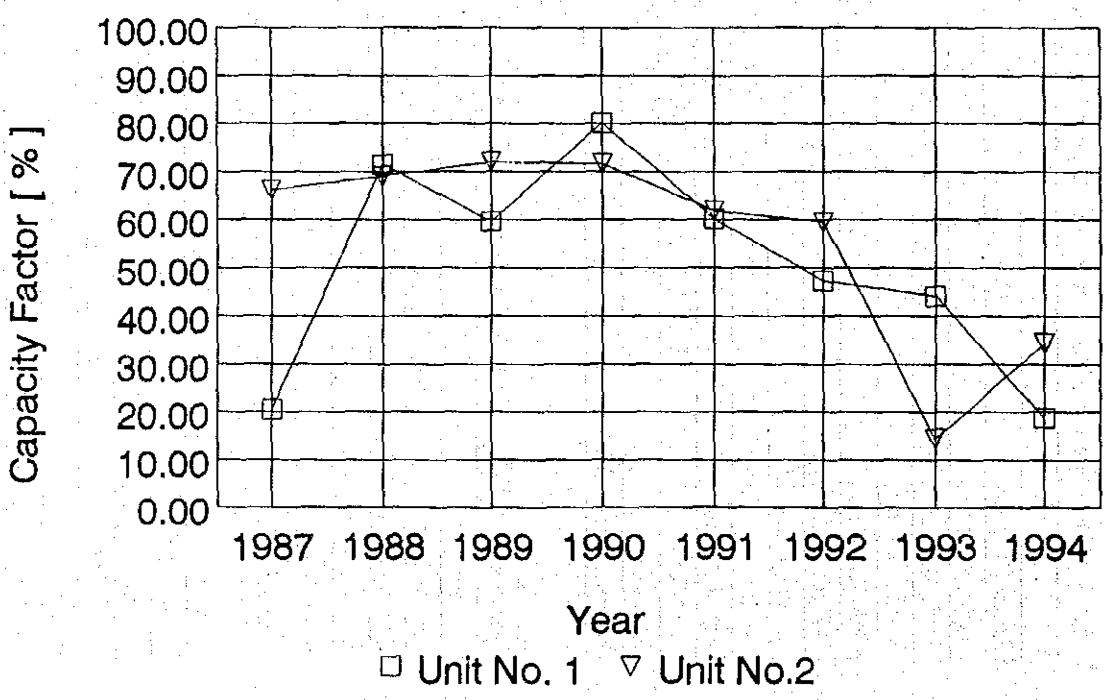


Figure 4-3 Malaya T.P.P Unit No.1
Operating Hours after Rehabilitation

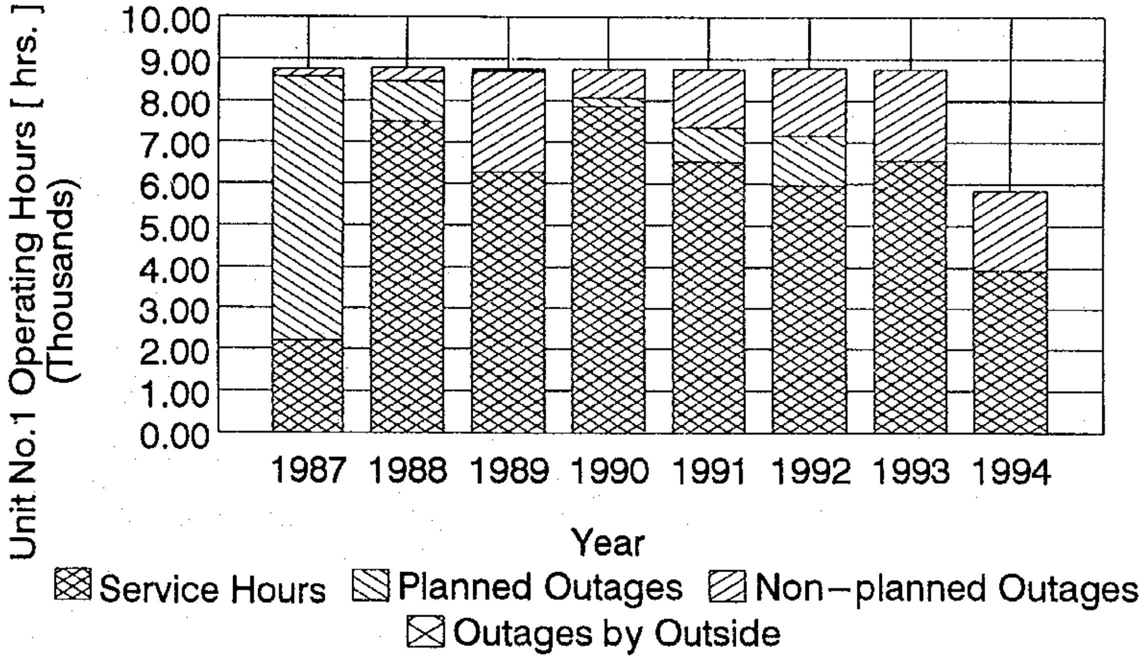


Figure 4-4 Malaya T.P.P Unit No.2
Operating Hours after Rehabilitation

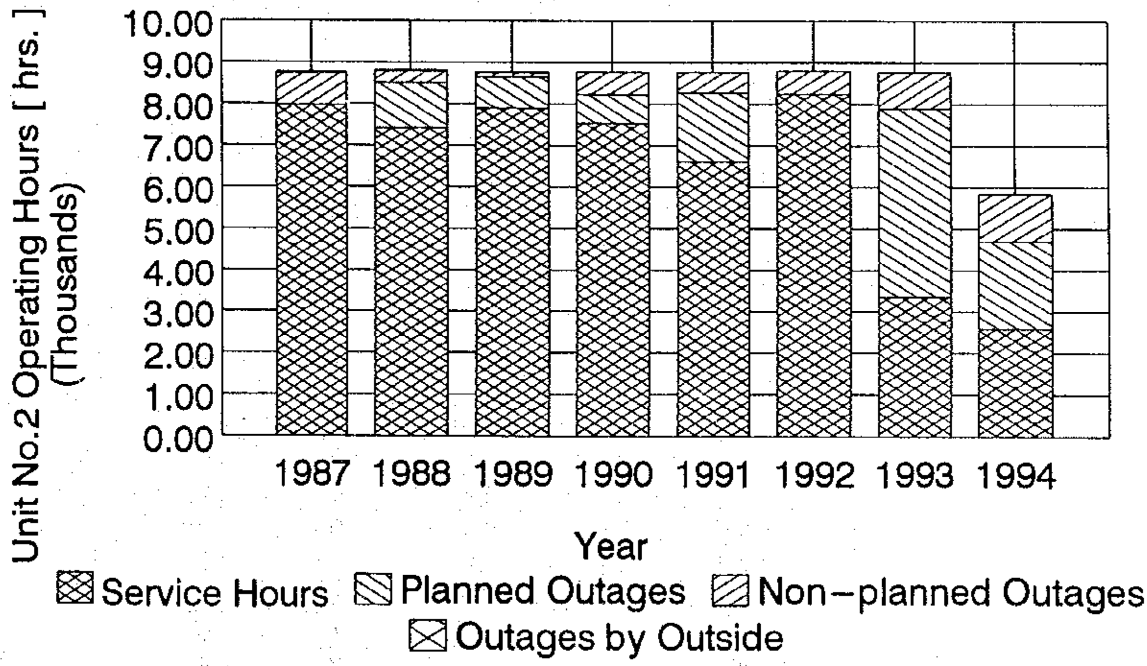


Figure 4-5 Malaya Thermal Power Plant
Average Load after Rehabilitation

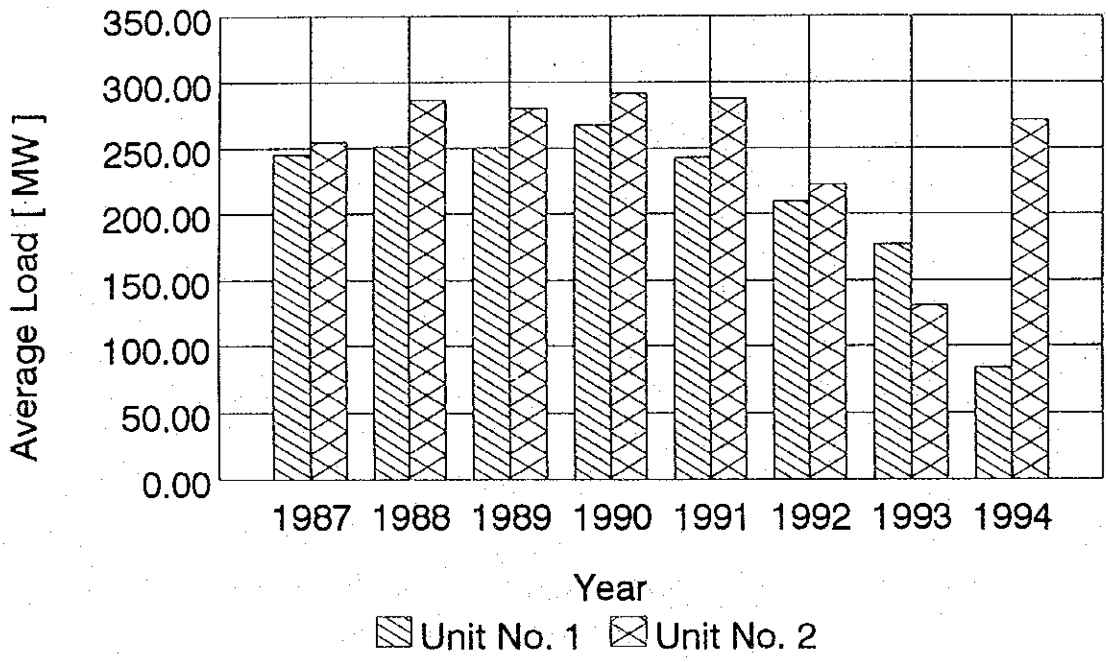


Table 4 - 5 Malaya Thermal Power Plant
No. of Start-up & Shutdown

	Unit No. 1		Unit No. 2	
	No. of Start-up	No. of Shtdown	No. of Start-up	No. of Shtdown
1974	1	1	---	---
1975	18	18	---	---
1976	20	19	---	---
1977	21	21	---	---
1978	37	37	---	---
1979	15	15	29	29
1980	21	22	17	17
1981	24	24	4	3
1982	30	30	20	21
1983	19	18	12	11
1984	14	15	10	11
1985	10	10	25	24
1986	13	13	19	19
1987	13	12	10	11
1988	15	15	10	10
1989	21	21	7	6
1990	20	20	15	16
1991	14	14	7	6
1992	16	17	7	8
1993	15	14	8	8
1994	7	8	7	6
Total	364	364	207	206

4.1.3 Maintenance Records

The Annual Overhauls of Malaya T.P.P. Units No. 1 & No. 2 have been implemented with a time schedule as shown in the Figure 4-6. The Annual Overhauls have been performed eleven (11) times in the twenty (20) year-operation since the commissioning in 1975 for the Unit No. 1, and seven (7) times in the sixteen (16) year-operation since the commissioning in 1979 for the Unit No. 2. In other words, the Annual Overhauls have been performed every two (2) years in average for both the units. The Annual Overhauls have not been carried out periodically. The overhaul intervals were often extent to two (2) to three (3) years.

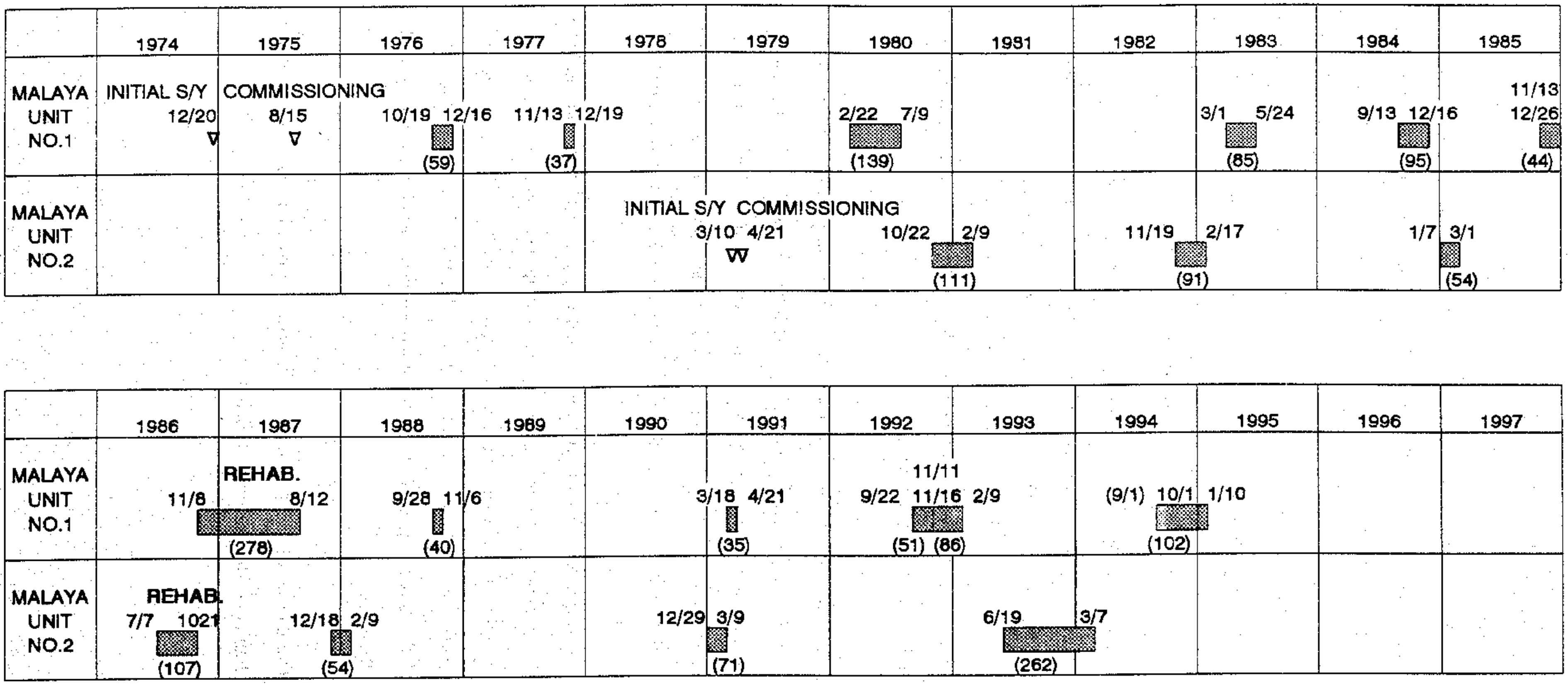
The Major Overhauls, in which whole turbines are completely disassembled for comprehensive overhaul, have been carried out two (2) times in 1980 and 1986 since the initial commissioning of 1975 for Unit No. 1, and those intervals are 4.5, 6 and more than 7 years respectively. For Unit No. 2 the Major Overhauls have been conducted in 1980, 1986 and 1993 in total three (3) times since the 1979 initial commissioning with intervals of 1.5, 5.5 and 6.7 years respectively.

The Preventive Maintenance has been frequently carried out between the Annual Overhauls. The Preventive Maintenance is scheduled for a short period repair of defective parts and malfunction of a system which are revealed during, unit operation to prevent a unit from forced outage. The Preventive Maintenance, however, trends actually toward symptomatic treatment for the revealed defects, instead of the preventive treatment what is called.

The Annual Overhaul must be carried out yearly to maintain performance and reliability of power plant facilities. In actual, the Annual Overhauls have not been carried out every year as mentioned above, and the performance and reliability can not be maintained due to the insufficient Annual Overhauls. These deterioration clearly appears in the operating records of the foregoing section as declined power generation, capacity factor, operating hours and efficiency.

The causes of the problems of insufficient overhaul works are studied in detail in the next chapter of the software division.

Figure 4-6 Malaya Thermal Power Plant Annual Overhaul Record



4.2 Present Conditions, Problems and Remedies

4.2.1 Mechanical Facilities

Both of Malaya TPP Units No. 1 and No. 2 have been suffering from violent gas leakage. High sulfur content in the fuel of 3 to 4 % causes low temperature corrosion and gas leaks in various places of the boiler casings, air pre-heaters and gas ducts. Leaked gas fills not only the boiler room but the turbine room causing secondary corrosion on various equipments in the building. It also impedes operators and maintenance staffs in daily patrol and maintenance. Periodic repair to stop gas leakage is necessary. Detailed inspection/record and study of repair method/frequency are also essential.

High quality fuel oil with low sulfur content should be considered to reduce low temperature corrosion and to improve environment.

1) Malaya TPP Unit No. 1

Facilities of Unit No. 1 are considerably deteriorated because no major overhaul has been done since the rehabilitation in 1987. Their deterioration seems about the same as that before the rehabilitation in 1987.

Deterioration of furnace water wall tubers are considered to be severe, though damaged portions are replaced at the rehabilitation in 1987. Sample tube analysis, visual inspection and tube wall thickness measurement are needed. Replacement and chemical cleaning of all water wall tubes are recommended from experiences in rehabilitation projects of Malaya TPP and Sucat TPP.

One (1) sample tube was taken from the waterwall and examined in detail on appearance, dimension, cross section microstructure, hardness and interior scale in Japan. The examination revealed a large amount of interior scale of 70 mg/cm^2 with the primary component of Fe_3O_4. The scale quantity suggests the necessity of a boiler chemical cleaning.

Conspicuous deterioration was not found except the interior scale mentioned above. Since the sample tube was taken from only one location for this examination, the sample tubes will have to be taken from several locations with systematic study and planning in order to ascertain the tube conditions and to judge the results of water management.

Averaged life time of the air pre-heater elements is only about 2 years.

Ash handling system which is now water slurry type is severely damaged by low temperature corrosion, and requires renovation with consideration for water pollution.

Inner lining of the smoke stack is damaged. complete replacement of the inner lining and rehabilitation of outer paintings are needed.

Major overhaul for HP and IP turbines should be urgently executed since it has not been done after the rehabilitation in 1987. Cracks on the heat grooves of IP turbine rotor requires detailed inspection. The IP turbine rotor may have to be replaced. Rotor blades of last two stages in LP turbine are cut due to crack problems. This crack problem has been exist since before the rehabilitation in 1987, and requires an essential countermeasure based on information from the original manufacturer.

Remaining life diagnosis for major equipments are necessary because Unit No. 1 has been operated over 100,000 hours.

2) Malaya TPP Unit No. 2

Unit No. 2 has not so many problems thanks to the major overhaul and extensive rehabilitation works executed from June 1993 to May 1994. Same countermeasures as Unit No. 1 are necessary to reduce low temperature corrosion in air pre-heaters, ash handling system and smoke stuck.

Remaining life diagnosis for major equipments are necessary because Unit No. 2 has been operated over 100,000 hours.

3) Common Facilities

The auxiliary boiler does not achieve rated performance, because accumulated ash on tubes near mud-drum causes corrosion and many tube leaks. Auxiliary boiler is indispensable for start-up of Unit No. 1 during shut-down of Unit No. 2.

Steel sheet piles are corroded and damaged, and need to be replaced.

4.2.2 Electrical Facilities

What can be stated in general regarding electrical facilities are that, except for the equipment, meters and relays located in the centralized control room and electrical equipment room for which air conditioning is provided, electrical facilities in both of boiler room and powerhouse are exposed to gases leaking from boilers and gas ducts. Accordingly, advanced contamination and deterioration can be found on many electrical facilities due to dust and SO_2 gases. It is necessary to urgently perform clean-up and detail inspection with all of the electrical equipment, in order to extract deteriorated points, to determine the points of replacement or repair, and to plan and implement necessary work.

As long-term countermeasures, it is essential to perform periodic cleaning and inspection, to repair gas leaking points of boilers and to take measures for preventing gas leakage from boilers.

The principal problems with the electrical facilities of Malaya Unit No. 1 and Unit No. 2 are described below.

1) Malaya Unit No. 1

a. Generator

The generator of Malaya unit No. 1 involves considerably large problems as stated below.
The problem of hot spot, that is, core end overheating on the stator in particular is large. Even if a temperature sensor was provided at the subject during rehabilitation of last time to permit monitoring of the extent of temperature rise. But due to shortage of the budget, complete measures were not taken, and there is a possibility where the limit temperature of the stator coil is exceeded due to failure and erroneous operation of the excitor. It is therefore desirable that stator modification work, which is identical to what was implemented with Sucat unit No. 4, is implemented as early as possible.

The exciter was originally of brushless type made by Siemens. But modification to static type was proposed when an excitor rotor bind wire failure accident occurred in 1987, and modification work was implemented in 1989. However, problems such as sparking from the slip ring occurred during running after modification. As a result, the excitor is not used as static type but is used at the present time as returned to the state before the modification. The automatic voltage regulator (AVR) should also be replaced because it is deteriorated as exposed to furnace gases leaked from boilers for a long time.

Failure to the excitor occurred when a period of ten years elapsed since commissioning of Malaya Unit No. 1. As no problems occurred to the brushless type excitor of Sucat unit No. 4, which employs an excitor of the same type as Malaya Unit No. 1, and no problems occurred to the brushless type exciters of Sucat Unit No. 2 and 3, it can be hardly considered that there are problems in the design of the excitor, and it is considered that sufficient troubleshooting should be made instead of modification to static type.

Furthermore, damage was found at bearing No. 8 journal shaft of the generator rotor, and there is a fear that jack-up of the shaft becomes insufficient. Therefore, detail inspection and repair should be made during the overhaul of this time (September through November, 1994).

b. 4,160V Metal-Clad Switchgear and 480V Switchgear

Extension is required because spare switch units are not used any longer.

c. 4,160V and 480V Motors

The bearing temperature of FDF motors 1A and 1B (4,160V) is high, and troubleshooting and countermeasures are required. Furthermore, abnormal vibration was found with raw water pumps 1A, 1B (480V). They also require countermeasures.

2) Malaya Unit No. 2

The electrical facilities of Malaya Unit No. 2 do not involve critical problems. But the following can be raised as items requiring improvement.

a. 4,160V Switchgear and 480V Switchgear

There are no critical problems. But since spare units are already used for others, addition of a spare unit is required for each of 4,160V switchgear and 480 V switchgear.

In addition, 480V Motor Control Centers are deteriorated and draw-out type units are misaligned. Total replacement is recommendable.

The transformer for the power center (2,000kVA) is of insufficient cooling and overheat occurs at occasions. Therefore, addition of a fan to the existing transformer or replacement with a mold transformer (for fire prevention) will be examined.

b. 4,160V and 480V Motors

Damage was found on the stator core of the 4,160V CWP-2A motor. If replacement of the motor is required it should be examined upon detail investigation during overhaul.

The bearing temperature of 480V stator cooling water pump motors (3,600 rpm) 2A, 2B is high, and examination of countermeasures is required.

3) Common Facilities

a. 230kV Substation

The disconnecting switch is of manual operation on the field at the present time. But it is necessary to replace it with a motor-operated type for labor saving in the conduct of the substation and also improving the safety (particularly on rainy days).

b. Internal Illumination

The illumination in the power plant is dark because of shortage of facilities and insufficient maintenance, and there are many places where dark illumination is a problem from the standpoints of patrol inspection and safety. Review and consolidation of illumination facilities particularly at points requiring inspection during patrol and passages of the boiler room should be made urgently.

4.2.3 Instrumentation and Controls

As general situations of the instrumentation and control facilities, corrosion and contamination due to gases leaking from boilers and gas ducts and found like electrical facilities. It is considered that cleaning, discovery of faulty points and repair to equipment are urgently required.

However, all of the troubles found in those days were corrected by the rehabilitation work conducted in 1986 - 1988 period and special repair was made to Unit No. 2 for the period of about eight months beginning in July 1993. Accordingly, the number of faulty points which became clear as a result of the investigation of this time was relatively small.

In a long-run, repair to gas leaking points of the boilers and gas ducts as well as permanent gas leakage preventing measures are required as described in the section of electrical facilities.

The principal problems with the instrumentation and control facilities of Malaya Unit No. 1 and Unit No. 2 are described below.

1) Unit No. 1

a. Steam Coil Air Heater Control

The air temperature does not rise to the specified level. Troubleshooting and countermeasures are required. NPC expressed the opinion that replacement of the steam coil is required. But it is considered better to carry out detail investigation to determine if the temperature control side involves no problem.

b. Corrosion to Control Air Pipeline

The control air was not dry enough and was of high humidity before the rehabilitation of 1987, and accordingly, the interior of the control air pipeline was corroded. Since the pipeline was almost unreplaced, rust is still contained in the control air, and it is necessary to replace the pipeline to eliminate the cause for this problem To determine which portions are to be replaced during the work of next time, pipe samples will be collected from a number of places to carry out investigation. Replacement of necessary portions will be made after this investigation.

c. FDF 1B Inlet Vane Control

High vibration is occurring with a unit load of 50% and up. It is necessary to perform troubleshooting during the overhaul of this time.

d. GRF Inlet/Outlet Damper Control Actuator

The actuator for inlet/outlet damper control has deteriorated and its operation is faulty. It is necessary to replace this actuator.

e. Reheater Spray Valve Seat Leak

Leakage from the reheater spray valve seat was found. It is recommended that the spray control valve is replaced with a valve of new type adopted for Sucat unit No. 4, as it is of less seat leakage.

f. Boiler Metal Temperature Measurement

Both of the thermocouple and recorder have deteriorated and require replacement. It is desirable that a recorder of hybrid type is adopted from the aspects of accurate temperature reading and alarm transmission.

g. Smokestack Monitoring TV

The smokestack monitoring TV has deteriorated and failed. It should be replaced.

h. Soot Blow Steam Pressure Control

The controller is out of order, and requires replacement.

i. Mini-Flow Valve Control for Turbine-Driven Boiler Feed Water Pump

At the time of switching from M-BFP to T-BFP at start of the unit, because of the fact that this mini-flow valve is of ON/OFF control, the rate of water feed to the boiler largely varies when the valve operates, and the unit output also varies accordingly. Therefore, stable running is disabled. It is used by manual control only at the present time due to this reason.
Re-examination of the control system is needed to permit automatic running. A new improvement plan will be considered using the modification plan adopted for Sucat unit No. 4 as a reference.

j. Drain Level Control of L. P. Heater No. 3

The control valve should be replaced, as its grand leak and seat leak are excessive.

k. Cold Reheat Drain Level Control

This control is not applied at the present time and manual control is made. It is recommended that automatic control be newly provided.

l. HSCC Make-up Water Level Control

Since automatic water level control is out of order, troubleshooting will be made and necessary countermeasures will be taken. (It is considered that the positioner has failed.)

2) Unit No. 2

a. ABC System

The currently installed ABC is an old pneumatic type and it is hard to acquire its spare parts. Therefore, it will be replaced with a new INFI-90 system (made by Bailey) of digital type.

b. Control Air Pipeline

As the interior of the pipeline is corroded like Unit No. 1, the situations of the pipeline will be investigated and necessary portions will be replaced.

4.2.4 Chemical Facilities

1) Malaya Unit No. 1

Condensate polishing plant needs complete overhaul and restoration of automatic control. Use of a magnetic filter is recommended to improve feedwater quality. A magnetic filter was installed in Sucat TPP during the rehabilitation project, and provided incredible effect to remove iron during start-up.

Detailed overhaul is needed for demineralizer and pre-water treatment plant because no major overhaul has been done since installation during the rehabilitation project in 1987. Silica analyzer should be restored as soon as possible.

Raw water is supplied to the demineralizer from deep wells. Deep well water will decrease and degrade as the well is used longer. Although the demineralizer was designed for the lake water, sea water brought into Laguna Lake during draught season make it difficult to get raw water from the lake. Study and measures for stable water supply are required.

2) Malaya Unit No. 2

Sampling lack is aged and should be replaced for accuracy of water quality control.

4.3 Rehabilitation and 5-Year Overhaul Plan

4.3.1 Outline of Project

1) Effects of Project

a. Recovery of Rated Output

The unit output will be recovered to 300 MW for Unit No. 1 and 350 MW for Unit No. 2.

b. Recovery of Plant Efficiency

The efficiency will be recovered to a 1988 value after the previous rehabilitation project.

c. Improvement of Reliability

The reliability will be improved, and the units can be operated with a higher capacity factor in 1988 after the previous rehabilitation project.

d. Service Life

Both the units will be operated until the originally scheduled retirement year, 2005 for Unit No. 1 and 2009 for Unit No. 2.

2) Major Work Items

In order to obtain the project effects mentioned above, the following major works should be carried out in addition to the comprehensive overhaul work of the power plant facilities of the Major Overhaul.

a. Malaya Unit No. 1

Plant Facilities	Major Work Items
Boiler	- Replacement of whole water wall tubes. - Boiler chemical cleaning - Examination of secondary superheater - Complete repair of boiler casing and gas duct - Replacement of heating elements of air pre-heater - Improvement of dust collection and ash handling system - Rehabilitation smoke stack inner lining - Study on fuel additive injection - Installation of additional sootblower at secondary superheater section
Turbine	- Life expectancy analysis (HP-, IP- & LP-turbines, Major Valves, Main steam pipe, Reheat steam pipe) - Comprehensive overhaul of HP-turbine or replacement with higher efficiency HP turbine - Comprehensive overhaul of IP-turbine - Replacement of IP-turbine rotor - Comprehensive overhaul of LP-turbine and replacement of cut blades - Eddy current test of condenser tubes - Replacement of tube handle of LP feedwater heater or replacement of complete assembly - Replacement of condensate distributor of deaerator or replacement with spray type deaerator - Replacement of circulating water pump - Installation of additional plate type heat exchanger
Electrical Facilities	- Repair of generator stator core end - Installation of spare 4160V switchgear cubicle - Installation of spare 480 switchgear cubicle
Instrument & Control Facilities	- Replacement of boiler metal temperature recorder, etc. - Replacement of control valves and instruments - Improvement of minimum flow control of boiler feed pumps

a. Malaya Unit No. 1 (cont'd)

Plant Facilities	Major Work Items
Chemical Facilities	- Recovery of automatic operation of condensate polishing plant and comprehensive overhaul - Installation of magnetic filter - Establishment of steady raw water supply system to demineralizing plant - Replenishment of chemical apparatus for laboratory

b. Malaya Unit No. 2

Plant Facilities	Major Work Items
Boiler	- Replacement of boiler hopper tubes - Replacement of superheater spray nozzles - Replacement of feedwater stop valve at economizer inset - Complete repair of boiler casing and gas duct - Replacement of GRF rotor - Replacement of heating elements of air pre-heater - Replacement of defective sections of steam coil air heater - Improvement of dust collector and ash handling system - Rehabilitation of smoke stack inner lining - Study on fuel additive injection - Life expectancy analysis of main steam pipe and reheat steam pipe
Turbine	- Comprehensive overhaul of HP-, IP- & LP-turbines and life expectancy analysis - Eddy current test of condenser tubes - Replacement of raw water pump for heat exchanger
Electrical Facilities	- Replacement of whole 480V motor control center and others
Instruments and Control Facilities	- Replacement of GRF damper controller - Replacement of automatic boiler control (ABC) and others
Chemical Facilities	- Replacement of whole sampling rack
Common Facilities	- Replacement of auxiliary boiler tubes and countermeasure for corrosion - Installation of concrete sheet pile at intake channel

4.3.2 Implementation Plan

The reliability improvement plan for power generating facilities is targeted to be completed 5 years after the JICA survey. Reliability of the power plant can be improved and maintained by the generating facilities recovered to normal condition through the effective combination of rehabilitation, which includes large-scale improvement and replacement work, and regular annual overhauls before and after rehabilitation and by improvement of consolidated software including improvement of operation and maintenance methods. The project schedule is shown in Figure 4-7.

A major overhaul will be conducted in the first year after the JICA survey, and any deficiency will be identified. The main objective will be the main equipment including the boiler, turbine and generator, and auxiliary equipment. Regarding the main equipment, inspection and report by engineers from the original manufacturers should be significant. The Unit No. 1 has been operated for 20 years since commissioning, and the Unit No. 2 for 15 years. The total operation hours of each unit has already exceeded 100,000 hrs. Thus, it will be necessary to check for deterioration and diagnose the remaining service life (creep, fatigue) of the equipment sections exposed to high temperatures, pressure, or stress. If the diagnostic results of the remaining life should suggest replacement of the main equipment (turbine rotor, casing, turbine valve, main steam pipe, hot reheat pipe, etc.) during rehabilitation, early procurement should be arranged considering the delivery time and other factors. This first major overhaul will determine the contents of future annual overhauls, and rehabilitation work as well as those implementation schedule.

For the second overhaul, relatively short-term inspection and repair mainly for boilers will be conducted. Sections left uninspected during the first major overhaul and the degree of deterioration, etc. will be checked, and the results will be referred to implementing rehabilitation.

The third overhaul will be the rehabilitation. In accordance with the execution plan, the problem sections will be completely repaired or replaced, or the improvement work of the system will be carried out. From the points of view of quality, reliability and schedule of the work, it is recommended that the original manufacturers join the rehabilitation work.

One year after the completion of rehabilitation, a simplified annual overhaul will be conducted to check the sections repaired, replaced, or improved during rehabilitation. The sections, found defective yet which had not been completely rectified during rehabilitation, or those found defective after rehabilitation shall be provided with proper measures to eliminate any problems.

Two years after rehabilitation, a major overhaul will be conducted to perform an inspection for each section. The sections repaired or replaced during rehabilitation, including those given an inspection during the annual overhaul a year later will be checked. Depending on the inspection results, improvements in operating methods and the contents of the next overhaul will be studied. If the overhaul two years after rehabilitation does not fit within the time-frame of the 5-year overhaul plan, an overhaul one year after will be counted as the major overhaul and the above-mentioned detailed inspections will be performed.

In tandem with the execution of the above-mentioned overhaul, funding, procurement/purchase procedures for equipment and materials needed for overhaul and rehabilitation, and work execution plans shall proceed.

After the completion of JICA survey, and implementation program shall be made and a loan application shall be submitted to the prospected financial agency. Immediately after a preliminary offer (P/O) is issued by the financial agency, the bidding documents shall be drawn up and preparations for the rehabilitation project and bidding shall be completed. The bidding documents shall be made based on the first overhaul results after the JICA survey.

The rehabilitation project contract will be signed in the first half of 1996. Considering the design and production periods, the rehabilitation work will be executed from sometime in the latter half of 1997 to the first half of 1998. During the overhaul following rehabilitation, the contractor's engineers who conducted the rehabilitation will carry out a fact finding inspection to ensure post-rehabilitation maintenance for the power generating facilities.

In addition, engineering services will be carried out with the assistance of a consultant in proceeding with the project .

4.3.3 Project Procurement

The Project is implemented within 5 years after completion of the JICA study. The Project consists of two times of overhauls of pre-rehabilitation for determine the scope of works of rehabilitation, and overhauls of post-rehabilitation for follow-up of rehabilitation works.

The rehabilitation project is undertaken by contractor(s) with turn-key basis. The contractors are selected through bidding. The overhaul works of pre-rehabilitation and post-rehabilitation are conducted by NPC.

The cost for overhauls of pre-rehabilitation is prepared by NPC separately from Rehabilitation cost, and includes expenses for dispatch of fact finders from original manufacturers and for life expectancy analysis of major equipment. The cost for Rehabilitation and overhauls of post-rehabilitation is procured from the loan. The Japan EXIM Bank is tentatively assumed to be one of prospected fund sources for the Project in this report.

4.3.4 Project Cost and Disbursement Schedule

1) Cost Estimate

The Project cost is tentatively estimated in this report and does not include the cost for software improvement yet. The cost consists of Foreign Currency Portion and Local Currency Portion. The project cost will be expressed in US dollar at following exchange rate.

As of September 1994

US Dollar	Japanese Yen	Philippine Peso
1	100	26.3132

Source: InterBank

2) Price Escalation

The project schedule up to completion from this feasibility study is shown in sub-chapter 4.3.2 above. Since it is estimated to take 5 years from the month of cost estimate, the following price escalation is considered in the cost estimate up to the completion of the project.

	Annual Average Rate
Escalation rate for FC	3.0%
Escalation rate for LC	9.9% (As of Sep. 1994)

3) Project Cost

The total required fund for implementation of the Project is listed in Table 4-21 and the disbursement schedule is shown in Table 4-22. The estimate conditions are described below:

a. Tax and Duty

The taxes and duties on imported equipment will be exempted in the nature of the project as a national development project.

b. Consulting Fee

For preparation of tender documents, assistance in evaluation of tenders, supervision of rehabilitation works and commissioning, a consultant will be hired and the cost is included in the Project Cost.

c. Physical Contingency

The rehabilitation project like this often involves additional equipment supply and services which could not be expected in this FS or later stage at preparation of tender documents. To cope with such circumstances, a contingency of 10% to the total cost is appropriated.

Table 4-6 Project Cost

[Unit: Thousand US$]

Items	UNIT NO. 1			UNIT NO. 2			UNIT NOS. 1 & 2		
	F. C.	L. C.	TOTAL	F. C.	L. C.	TOTAL	F. C.	L. C.	TOTAL
1. Rehabilitation cost	96,134	5,161	101,295	36,817	1,977	38,794	132,951	7,138	140,089
2. Consultant fee	3,580	188	3,768	1,170	62	1,232	4,750	250	5,000
3. Total project cost	99,714	5,349	105,063	37,987	2,039	40,026	137,701	7,388	145,089

Table 4-7 Disbursement Schedule

[Unit: Thousand US$]

	1995	1996	1997	1998	1999	Total
Unit No. 1	1,815	15,746	55,316	30,373	1,814	105,063
Unit No. 2	1,586	5,862	30,464	1,057	1,067	40,026
Total	3,401	21,608	85,779	31,430	2,871	145,089

4) Fund Procurement

a. Procurement Method

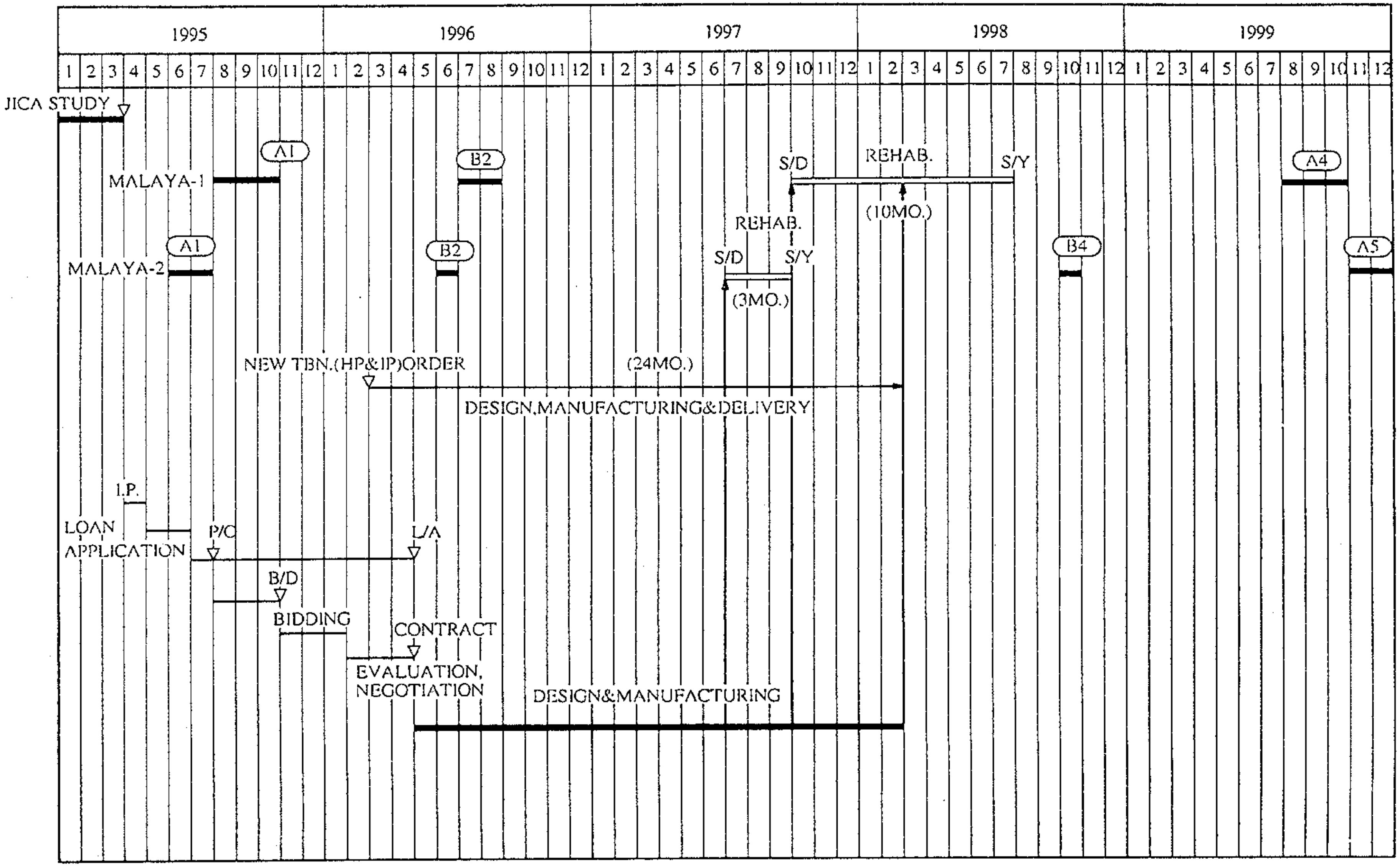
The Japan EXIM Bank is assumed to be a prospected fund source for the Project in this report tentatively.

b. Loan Conditions

Source	Interest/Rate of Return	Repayment Period	Grace Period	Commit. Fee
Equity	8%			
Local Loan	NA (14% Inter Bank Rate as of July 1994)			
Exim Japan	5.8%	10 years	None	0.5%

MⓁ96

Figure 4-7 Rehabilitation & 5-Year Overhaul Schedule



LEGEND : A : MAJOR OVERHAUL
B : ANNUAL OVERHAUL (MINOR OVERHAUL)

CHAPTER 5

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

CHAPTER 5. IMPROVEMENT PLAN OF POWER PLANT OPERATION AND MAINTENANCE MANAGEMENT (SOFTWARE)

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 Manual

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.

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	(1)	
G/T)	1	3/4
Sr. Control Operator B	1	2/4
Electrician, Control Operator B		
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.

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 p.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.

e. 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

5.1.2 Maintenance Management

1) Maintenance Procedure

a. Current Status of Managed Maintenance Program (MMP)

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

Regarding thermal power plants, MMP's 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
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

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%.

c. Maintenance Procedure

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) The Result of the Study on Malaya TPP Maintenance Procedures

Administrative procedures

- Procedures related to laws

  In Japan, many of the administrative procedures related to power plants are specified under laws, and they include technical specification for equipment and inspection procedures.

  (Example)

  - Electric Utility Law
    - Technical standard related to equipment for power generation
    - Periodic inspection

  It seems necessary for NPC to create administrative procedures as what substitute for these acts. No procedures were found up to now equivalent to such administrative procedures.

Technical Standards and procedures

- 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.

- MSD has completed overhaul manuals of 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 schedule and contents of periodic inspections for boilers and turbines.

2) Daily Maintenance

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

"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."

b. MMP at Malaya TPP

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 boiler main unit and burners and their surroundings are to be involved in addition to the above;
- The inspection frequency is about the same between Malaya TPP and Japan, and weekly inspection and monthly inspection are conducted. Same hereinafter.

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.

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;
  Inspection of generators, transformers, and high/low voltage motors, measurement of insulation of principal equipment, etc.

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.

c. Situations of Conduct of CM Program at Malaya TPP

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, repair will be requested to MSD.

3) Periodic Overhaul and Preventive Maintenance Planning

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 are not carried out as planned. This is because of repeated postponements due to an aggravated power supply, a situation which is exacerbated because there are no regulations. Also, there are no standardized inspection items for periodic inspections. In order to carry out long-term management of equipment, it is imperative to establish the standards and know-how to implement a thorough periodic overhaul plan.

b. Departments Responsible for Periodic Inspection Planning

a) Draft plan is prepared by the plant (Contents of Work, Period, Time of implementation)

b) Operations Projects Services Dept. of MMRC coordinate the plans from all the thermal power plants.

c) System Operations Dept. will determine the time of periodic inspections of all plant.

c. Preparation for Overhaul

a) 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.

b) 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.

d. Preventive Maintenance Plan

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.

e. Management of Maintenance Record

Records of equipment troubles, repair, modification, etc. are kept as overhaul records. But no arrangement has been made in such a manner that the history of each equipment since construction can be learned at a glance, such as ledger of history of equipment maintenance for each equipment is not available. Such recording was adopted since 1992 for major rotating equipment.

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. 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 rather in the form of digest and no safety management or quality control are included in them.

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

c. 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.

d. Present Status and Future Plan of Overhaul Interval

It was initially scheduled that annual overhaul be implemented every year at each thermal power plant of NPC in past 10 years. 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.

e. Overhaul Records

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

f. Organization and Structure for Overhaul Work

A functional structure specific to overhaul of Malaya TPP was produced. See Figure 5-2.

g. 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. 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.

h. 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.

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.

Figure 5-2 Malaya 1 Overhaul Table of Organization (September 1 to December 10, 1994)