<table>
<tr><th colspan="2">ITEM</th><th>G–1</th><th>G–2</th><th>S–1</th><th>S–2</th><th>M–1</th><th>M–2</th><th>Engineering</th><th>Remarks</th></tr>
<tr><td rowspan="3">Management</td><td>Making of monthly report about water analysis</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td>As soon as possible</td></tr>
<tr><td>Foundation of central laboratory</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td></td></tr>
<tr><td>Intensification of management</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td>As soon as possible</td></tr>
<tr><td rowspan="10">Demineralizer</td><td>Replacement of conductivity meters and recorders</td><td colspan="4">◎</td><td colspan="2">◎</td><td>–</td><td>Immediately</td></tr>
<tr><td>Replacement or repair of flow meters and recorders</td><td colspan="4">◎</td><td colspan="2">◎</td><td>–</td><td>– do –</td></tr>
<tr><td>Repair or replacement of control system for automatic operation</td><td colspan="4">○ P</td><td colspan="2">○ P</td><td>Ⓜ</td><td></td></tr>
<tr><td>Additional demineralizer</td><td colspan="2">S</td><td colspan="2">◎ P</td><td colspan="2">◎</td><td>Ⓔ</td><td>GSTP-ordered
MTP-immedi-ately (Plan)</td></tr>
<tr><td>RO unit</td><td colspan="4"></td><td colspan="2">◎</td><td>Ⓔ</td><td>Immediately (Plan)</td></tr>
<tr><td>Overhauling and resin make-up</td><td colspan="2">S</td><td colspan="2">◎ P</td><td colspan="2">◎ P</td><td>Ⓔ</td><td></td></tr>
<tr><td>Improvement of regeneration process</td><td colspan="4">◎</td><td colspan="2">◎</td><td>–</td><td>Immediately</td></tr>
<tr><td>Improvement of water analysis</td><td colspan="4">◎</td><td colspan="2">◎</td><td>–</td><td>– do –</td></tr>
<tr><td>Using of Laguna Lake Water</td><td colspan="4"></td><td colspan="2">◎</td><td>Ⓔ</td><td>Immediately (Plan)</td></tr>
<tr><td>Neutralizing equipment</td><td colspan="4">○</td><td colspan="2">○ repair</td><td>Ⓔ</td><td>As soon as possible</td></tr>
</table>

ITEM		G–1	G–2	S–1	S–2	M–1	M–2	Engineering	Remarks
<u>Condensate Polishing Plant</u>	Replacement of conductivity meters and recorders		◎	◎	◎	◎		–	Immediately
	Replacement or repair of flow meters and recorders		◎	◎	◎	◎		–	– do –
	Repair or replacement of control system for automatic operation		○ S	○ S	○ P	○ P		Ⓜ	
	H/oH-type operation		◎	◎	◎	◎		–	Immediately
	Additional regeneration equipment and replacement of condensate polisher		◎					Ⓔ	Ordered
	Using of higher quality caustic soda		◎	◎	◎	◎		–	Immediately
	Control of condensate pH		○	○	○	○		–	As soon as possible
	Improvement of regeneration process		○	○	○	○		–	– do –
	Resin trap for condensate polisher outlet		◎	◎	◎	◎		–	Ordered
	Improvement of water analysis		◎	◎	◎	◎		–	Immediately
	Overhauling, resin make-up and adjustment of resin level		◎ S	◎ P	◎ P	◎ P		Ⓔ	
<u>Secondary Water Treatment</u> a. Chemical injection equipment	Set up of conc. hydrazine injection equipment for lay-up	○	○	○	○	○	○	–	As soon as possible

ITEM		G–1	G–2	S–1	S–2	M–1	M–2	Engineering	Remarks
b. Chemical Feed Control	Determination of ammonia injection by the measurement of conductivity		○	○	○	○		–	As soon as possible
	Automatic pH control		◎	◎	◎	◎		Ⓜ	Immediately (Plan)
c. Management of Chemicals	Making monthly reports about consumption	○				○		–	As soon as possible
	Improvement of storage condition	○				○		–	– do –
	Intensification of QC/QA	○				○		–	– do –
<u>Sampling Rack</u>	Set up of new sampling rack	◎	◎	◎	◎	◎		Ⓔ	Ordered
	Temperature control around 25°C						◎	–	Immediately
<u>Monitoring Instrument</u>	Set up of new monitoring instruments	○	◎	◎	◎	◎		Ⓜ	Ordered
	Intensification of management and maintenance	○	○	○	○	○	○	–	As soon as possible
	Improvement of instrument at M–2 and G–1 (cation conductivity monitor in CPD)	◎					◎	–	Immediately
<u>Cooling Water</u> a. House service closed cycle	Change of water quality analysis item	○	○	○	○	○	○	–	As soon as possible
	Injection of chemicals	○	○	○	○	○		–	– do –
	Check of sacrifical zinc plate	○ S	○ S	○ P	○ P	○ P	○ P	–	
	Improvement of leak test method	○	○	○	○	○	○	–	As soon as possible

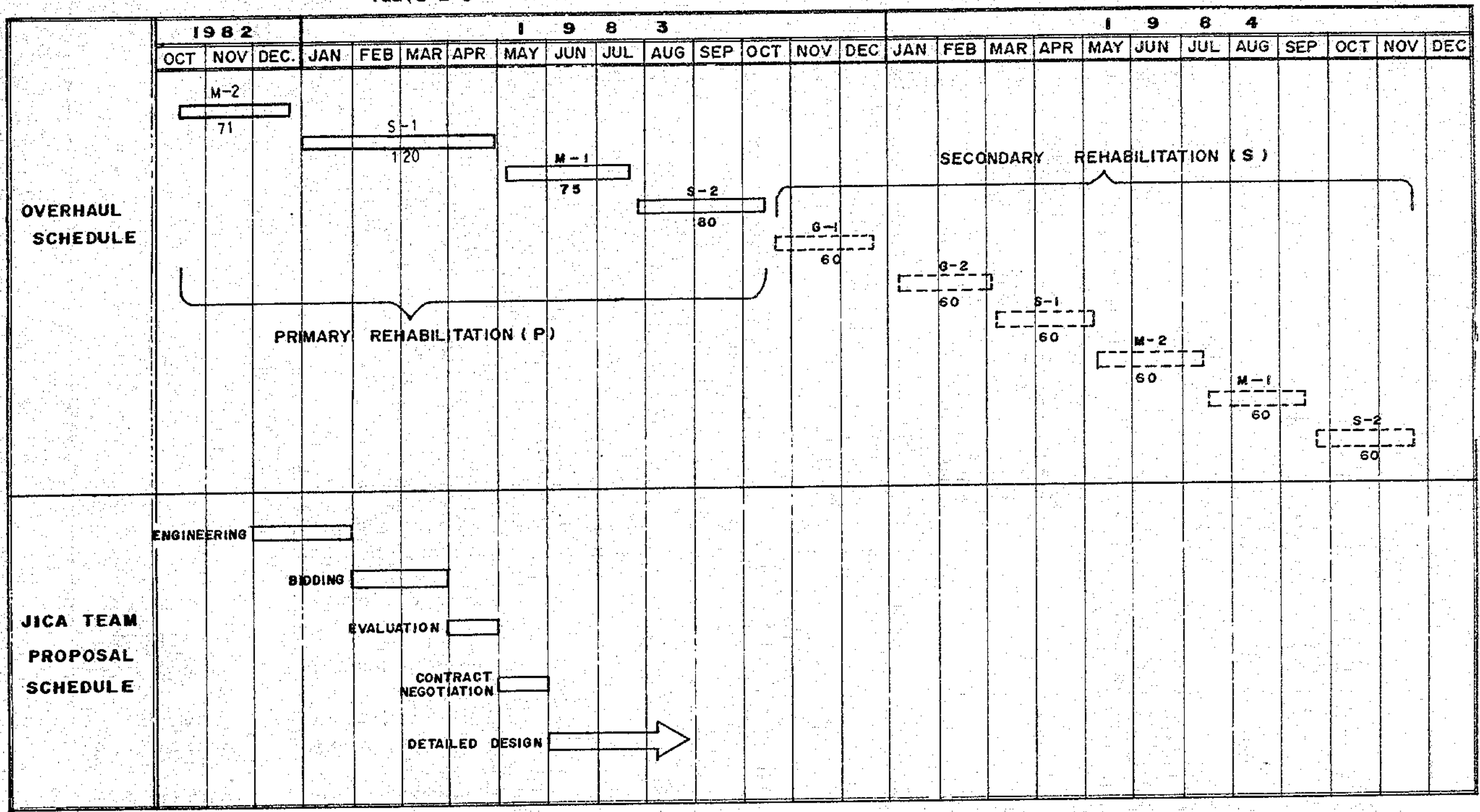
ITEM		G–1	G–2	S–1	S–2	M–1	M–2	Engineering	Remarks
b. Condenser cooling water	Repair of current cathodic protection equipment	◎ S	◎ S	◎ P	◎ P	◎ P	◎ P	–	
	Improvement of leak test method	○	○	○	○	○	○	–	As soon as possible
<u>Disposition of Abnormality in Feed Water</u> a. Unit start-up	Analysis and disposition of dissolved oxygen	◎				◎		–	Immediately
	H–OH type operation of condensate polisher.		◎	◎	◎	◎		–	– do –
	Installation of blowing pipe at the condensate pump discharge	◎ S	◎ S	◎ P	◎ P	◎ P	◎ P	–	
	Improvement of T–Fe analysis method	○				○		–	As soon as possible
b. Condenser leakage	Repair of CP out cation pass conductivity monitor	◎	◎	◎	◎	◎	◎	–	– do –
	H–OH type operation of condensate polisher		◎	◎	◎	◎		–	Immediately
	Improvement of chloride analysis method	◎				◎		–	– do –

<table>
<tr><th colspan="2">ITEM</th><th>G–1</th><th>G–2</th><th>S–1</th><th>S–2</th><th>M–1</th><th>M–2</th><th>Engineering</th><th>Remarks</th></tr>
<tr><td rowspan="5"><u>Overhauling</u>
a. Inspection in overhauling

b. Preservation treatment

<u>Boiler Chemical Cleaning</u></td><td>Inspection of equipments</td><td>S ○</td><td>S ○</td><td>P ○</td><td>P ○</td><td>P ○</td><td>P ○</td><td>–</td><td></td></tr>
<tr><td>Standardization of preservation treatment</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td>As soon as possible</td></tr>
<tr><td>Recheck of schedule</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td>As soon as possible</td></tr>
<tr><td>Change of place for test plate and test tube</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td>– do –</td></tr>
<tr><td>Improvement of displacement</td><td colspan="4">○</td><td colspan="2">○</td><td>–</td><td>– do –</td></tr>
</table>

Table 2-3 REHABILITATION SCHEDULE



NOTE: OVERHAUL SCHEDULE IN 1982, CASE 31, WAS SHIFTED TO 1983, & WILL BE IMPLEMENTED IN ACCORDANCE WITH **NAPOCOR** PLANNING OF 1982.

2.2.2 Boiler

Accidents in the boiler sometimes obstruct the continuous operation of a unit in accordance withthe past trouble records. At present, NAPOCOR conducted a study on boiler trouble together with the manufacturer, after that recommendations will be carried out in its rehabilitation program. JICA team commended the rehabilitation program of NAPOCOR. However, it is more important that unit should be continuously operated without any partial accident such as trouble on clogged AH elements, leakage of feedwater heaters, leakage of condenser tubes, etc. Therefore, the annual overhaul and the daily preventive maintenance should be properly and religiously carried out.

For the annual overhaul, JICA team recommends that NAPOCOR review the present organizational set-up and to obtain more flexibility. It is also very important to strictly carry out scheduled control, execution control and inspection/testing.

For the daily preventive maintenance, it is strongly recommended to NAPOCOR to carry out the routine maintenance works as in Appendix-2. JICA team saw plenty of steam, water and oil leakages, and plenty of malfunctioning control valves and instruments at the site. These troubles occurred due to imperfect maintenance work without any routine preventive maintenance work.

1) Boiler Proper

a. Present Conditions

At present, all units (Gardner/Snyder and Malaya) fall in boiler reduced pressure operation except S-2 which is in normal pressure operation.

Major problems are briefed as follows:

G - 1

Operation on boiler reduced pressure started in April 1981 and continues until now. The rate of reduced load is 66% (100 MW/150 MW). There were a plenty of leaky water wall tubes probably caused by overheating.

G - 2

Operation on boiler reduced pressure started in February 1981 and continues until now. The rate of reduced load is 70% (140 MW/200 MW).

All secondary SH panels were replaced, due to high temperature corrosion, in September 1982.

The RH tubes have some scaling, corrosion of inner tubes and high temperature corrosion even after the overhauling. Horizontal RH tube may also experience inner corrosion, hence inspection must be made.

The waterwall tubes also experienced high temperature corrosion. (This is now under inspection.)

S - 1

Operation on boiler reduced pressure started in November 1980 and continues until now. The rate of reduced load is 70% (140 MW/200 MW).

The secondary SH tubes and RH tubes are all experiencing high temperature corrosion. The phenomenon of reducing wall thickness could be similar to the result on G-2 overhauling. Horizontal RH inspection must be made same as G-2.

Moreover, the water wall tubes may also experience high temperature corrosion, hence, inspection must be made during a unit shutdown.

S - 2

Operation is presently on its rated pressure, however, this unit also experienced a reduced boiler pressure operation between January 1981 to April 1982. Rate of reduced load was 80% (240 MW/300 MW).

There are some reduced or dilated bulging secondary SH tubes. These tubes also had some scaling. Tube leakage occurred even after the overhaul of the unit.

The RH tubes has scaling and corrosion of the inner tubes. There are also some thinning of the tubes. Pitting corrosion was also observed in the water wall tubes.

M - 1

Boiler reduced pressure operation has continued since February 1982. The rate of reduced load is 80% (240 MW/300 MW).

There are some high temperature corrosion, reduced tube thickness and suspended scales in the secondary SH tubes.

There are thick and black scales on the surface of the RH tubes. Replacement of these secondary SH and RH tubes were arranged by NAPOCOR on the next overhaul.

There are also some bulging tubes in the water wall tubes.

M - 2

Operation on boiler reduced pressure started in April 1982 and continues until now. The rate of reduced load is 80% (280 MW/350 MW).

High temperature corrosion is also evident in the secondary SH and RH tubes. These tubes must be checked at the next overhaul.

Replacement of the baffle water wall tubes had been arranged by NAPOCOR for the next overhaul.

b. Recommendation

(a) Cautions for Reduced Pressure Operation

JICA team strongly recommends some points in carrying out the boiler reduced pressure operations: For once-through boilers, special attention should be paid to the flow of fluid in the boiler tubes. According to the manufacturer's report on variable pressure operation, correlation between boiler pressure and steam flow is very important. If reckless operation under the variable pressure is continued, the boiler will be seriously damaged.

In case of Malaya, M-1 is on variable pressure operation at 2,100 psig with a maximum load of 240 MW. Under the pressure, the maximum load must be kept less than 175 MW in accordance with the manufacturer's recommendation.

JICA team also advices NAPOCOR to follow the recommendations on variable pressure operation made by the manufacturer.

(b) Prevention of Tube Failure

Rehabilitation on boiler tube problems had been arranged by NAPOCOR. JICA team also studied about these problems as in description on Boiler in sub-section 5.3.1. Majority of boiler tube accidents were due to overheating and inner corrosion of tubes. The latter is caused by inappropriate water quality control.

Moreover, the SH and RH spray systems must always be maintained in good operating condition. Valve seat leakage is commonly experienced. It is important that the water quality should be controlled in conformity with the recommended limit value.

(c) Combustion Control

The residual oil presently used for fuel has a higher sulfur content. Hence the corrosion of AH elements are always experienced. Good combustion control should always be maintained for the boilers. For instance good automization of fuel and low excess O_2 combustion, which has effect to reduce SO_3, are necessary. However, if NAPOCOR carries out the low excess O_2 combustion, the maintenance of the O_2 analyzer is essential. Moreover, a routine check of Eco outlet O_2 by Orsat analysis and the control of the proper air flow, etc., must be made for all units.

The Constant Differential Fuel Oil Pump (CDFOP) must always be in service for good fuel atomization (G-1 and M-2).

(d) Control for Air Preheater

All units experienced big problems on AH corrosion and clogging. One of the methods to control this problem is to keep the average air-gas temperature on the AH cold-end higher than the limit temperature of the flue-gas dew point. The control system of the SCAH should be properly serviced by the maintenance personnel to keep the function of the SCAH in good condition.

JICA team also would like to recommend that the gross weight of the AH elements be measured for a new set before installation. By this measurement, NAPOCOR will be able to confirm the corrosion trend to know the time to order the spare elements for replacement.

Strict control of the air-leakage from the AH is also needed by measuring the excess O_2 in the AH outlet flue gas.

(e) Control for Sootblower

Presently, the rate of operation of the rack-type sootblower is very low.

These sootblowers must always be used to prevent high temperature corrosion and increase unit efficiency.

If magnesium hydroxide is used to reduce the SO_3, the rack-type sootblowers must be available to get rid of the ash on the tubes since magnesium hydroxide is better to be used in the separation of ash and the products of porous slag on the high temperature tube.

Furthermore, study the effect of magnesium hydroxide and its economical feasibility.

(f) Maintenance of Boiler Casing Gas Leakage

All units of NAPOCOR studied by JICA team on site, has plenty of flue gas leakage coming from the boiler casing. Flue gas corrodes all equipment, especially the electrical and control instruments, etc. It is detrimental on the health of all personnel.

Therefore, repair of the boiler casing gas leak must be made immediately, after that a standard leak test must be made.

(g) Deficiency of Insulation

There are plenty of defective pipe insulation at the site. These insulations are needed to prevent heat loss, protection of other equipment and safety of the patrols. Therefore, the insulation on each equipment and piping, especially all of the high temperature piping must be completed by the maintenance personnel.

2.2.3 Boiler Auxiliaries

Present conditions and recommendations are described below:

G - 1

FDF Reduced Capacity:

The following items should be checked, and compared with the design characteristic curves of the fan.

a) Air flow

b) Differential Pressure Air Heater

c) Ampere of FDF motor

d) Operating Condition of Control Drive Unit

S - 2

Use of two (2) full capacity Main Fuel Oil Pumps beyond 250 MW load due to difficulty in maintaining the fuel oil header pressure.

Operating condition should be checked by plotting pressure against capacity to determine actual condition of pumps and to clarify the cause of trouble.

M - 2 & G-1

Constant Differential Fuel Oil Pumps are not used, and they must be repaired immediately.

2.2.4 Turbine

In this study, it was clear that the turbine proper has a lot of problems, as indicated by the high incidence of shutdowns due to turbine troubles according to the past trouble record. These problems hinder the continuous operation of the unit. In the case of S-1, S-2 and M-1, the number of turbine troubles is more than those of the boiler. NAPOCOR has applied the counter-measures with the assistance of the manufacturer, but the cause of the turbine troubles should be re-studied and confirmed by NAPOCOR.

For the turbine equipments, the annual overhaul and the daily preventive maintenance should be properly and religiously carried out. This must also be done on the boiler equipment to ensure an efficient and continuous operation of the unit.

1) Turbine Proper

a. Existing Condition

At present all the main turbines has a big problem on the turbine blades except G-1 and M-2.

The major problems on each turbine are described in "Summary of Turbine Troubles."

Summary of Turbine Troubles

G - 1

No significant trouble of turbine from date of commissioning up to present.

Present Condition - All turbine blades are complete with no cuts.

G - 2

- HP turbine blade failure. One (1) impulse blade missing while all other remaining blades were badly battered and deformed at the trailing edges. Replaced all blades of HP turbine in 1971.
- Thrust bearing failure. Bearing was replaced.
- Blade failures at LP last stage. Cut broken blades and corresponding opposite blades.
- Present Condition - A total of six (6) blades at LP last stage (turbine end) were cut.

S - 1

- A series of blade failures occurred at the LP last stage on both turbine and generator sides. Cut the broken blades and their corresponding opposite blades.
- The existing X22CrMoV12 1 blade material of LP last stage was replaced by X20Cr13 with hardened edge in 1978.
- Again a series of blade failures occurred at the LP last and second to last stage plus damages to other turbine parts. Cause of blade failures were allegedly due to stress corrosion.
- Present Condition

  LP last stage (turb. & gen. side) - all blades have cuts.

  LP 2nd to last (turb. & gen. side) - all blades have cuts.

  LP 3rd to last (turb. side) - ten (10) blades have cut and one (1) blade vacant.

S - 2

- Damaged HP impulse blades. Replaced blades and other damaged parts.

  During the 1981 overhauling, many blades with crack were found at the LP 1 and LP 2 last and second to last stages. Cut all blades at said portion.

  Inspection conducted due to excessive vibration of the main turbine after overhauling shows extensive damage on HP turbine, impulse blade spindles of HPCV-1, 2 & 4 are broken, defective hangers caused the CRH pipe to lift the HP turbine. The HP rotor was replaced by the M-1 spare rotor, temporary hangers and pipe movement limiter were installed at the CRH and HRH lines. Repaired damaged parts of the HPCV's and replaced broken spindles with new ones. (modified design)

- Present Condition

  HP & IP turbines - with complete blades

  LP1 last stage (gen. side) - all blades have cuts.

  LP1 last stage (turb. side) - all blades have cuts.

  LP1 2nd to last (turb. side) - all blades have cuts.

  LP2 last stage - all blades have cuts.

  LP2 2nd to last - all blades have cuts.

M - 1

- Damaged turbine bearings. Replaced bearings with new spares.

  For a period of eighteen days, the unit was shutdown seven (7) times due to turbine balancing. Later inspection revealed a broken blade at LP1 last stage (gen. side) and four(4) broken bellows at the expansion joints in the cross over pipe to LP2. Cut broken blades and replaced damaged bellows with new ones.

- Present Condition

  LP1 last stage (gen. side) - four (4) blades have cuts.

  LP1 2nd to last (gen. side) - all blades have cuts.

  LP1 2nd to last (turb. side) - all blades have cuts.

M - 2

- Sudden tripping of M-1 and M-2 due to outside fault occurred on October 9, 1980. All bearings of turbine and generator were damaged. Replaced bearings with new spares. Damaged journals were machined.

- Present Condition

  All turbine blades are complete.

  Diameter of machined journals are less than their original value.

b. Recommendations for the Turbine Proper

JICA team was not able to conduct a detailed study on the turbine because of insufficient technical data. To take care of the turbine problems, JICA team would like to recommend the following items:

(a) HP-Turbine

i. An unexpected event on the operating conditions must be avoided for the protection of the impulse stage blade.

ii. It is necessary for NAPOCOR to obtain the Turbine Maintenance Instruction Data from the manufacturer. Whenever NAPOCOR carries its maintenance work, the maintenance personnel must refer to the Instruction Data.

(b) IP-Turbine

i. An unexpected event on the operating conditions must also be avoided for the protection of the stationary blades and the moving blades.

ii. The IP-turbine must always be operated under good steam conditions. It means that the boiler water quality must be kept within its limited value and that the RH spray control valve must be completely repaired by the maintenance personnel to prevent water leakage into the IP turbine.

It is recommended that NAPOCOR should request the manufacturer to submit the information and data on damage on inner casing in order to prevent recurrence.

(c) LP-Turbine

i. It is necessary for NAPOCOR to obtain some data from the manufacturer regarding the damage on the last stage blades and its adjacent blade stages. For instance, dehardening method of the blades, effect of its dehardening, etc. Furthermore, these data must be made available to the maintenance personnel.

(d) Bearings

i. An unexpected event on the operating conditions must be avoided for the protection of each turbine bearing.

ii. Turbine oil-flushing must be carried out with clear and accurate judgement on the oil standard. This must be done after an overhauling to prevent a big maintenance job on the turbine bearing. Turbine oil-flushing and insulation jobs must not be done simultaneously. However, should the jobs be done simultaneously, the correct counter-measures must be made.

2.2.5 Turbine Auxiliary

1) Condenser

a. Existing Condition

Checking of condenser tube leakage is not properly carried out in thermal plants which was observed in soap sud test at M-2 and eddy current test at G-2.

At present M-2 condenser has many plugged tubes; The plugged rate of A-Side is 31.5% and B-Side 14.0%. Inspite of this abnormal condition, the cause of this problem is not properly investigated. In general, the condenser vacuum is less than its rated value. This is not good.

b. Recommendation

(a) Eddy current test should properly be carried out to inspect condenser tube leakage during annual overhauling. This particular test will prove to be very effective in determining actual tube condition such as cracks and rate of corrosion/erosion on condenser tube walls if the proper test methods or procedures are strictly complied with. In Japan eddy current test is performed by professional companies and the test results are properly documented. Along this line, NAPOCOR can also train some of its personnel in eddy current test methods by initially availing of services of accredited companies.

(b) Regular checking must be carried out on the following items to ensure that main condenser vacuum is maintained at design or allowable levels.

i. Check the performance of the Air Ejector

ii. Check O2 content in the condensate water

iii. Check on possible air leakage to the condenser

iv. Maintain adequate sealing of valves that are directly connected to condenser vacuum lines.

This countermeasures will, to a large extent, assist in improvement of water quality.

(c) Thorough cleaning of main condenser tubes should be religiously carried out during overhauling or during scheduled unit shutdown. The use of appropriate cleaning device will ensure effective removal of algae clinging to inner tube walls and other foreign matters that had accumulated along the tubes.

(d) Frequent condenser back-washing should be done while the unit is operating to avoid fouling of condenser tubes. This will also greatly help in maintaining condenser efficiency.

2) <u>Turbine Lube Oil System</u>

<u>Routine inspection should never be neglected</u>. All noted turbine oil leakage must be immediately and adequately repaired by plant maintenance personnel. This is extremely necessary not to loss much oil from the system and not to leak oil into vacuum line. Oil leakage also adversely affects turbine equipment and can also serve as fire and accident hazard.

3) <u>Pipe Support</u>

Influence of piping weights (main steam pipe, RH pipe and extraction lines) on the turbine is a very important factor which must always be considered. Sometimes this stress can cause abnormal turbine vibration.

In some units, provisional support and hangers are being used. Instruction manuals and engineering data must be obtained from manufacturer so that these hangers can be improved or restored in accordance to design.

4) Auxiliary Steam

In some units, insufficient quantity of auxiliary steam at BFP-T start sometimes occurs due to inoperative local control system of the auxiliary steam lines. Therefore, it is necessary to exert all possible efforts to repair this local control system and restore them to normal operating condition. Studies should also be conducted whether the capacity of the present auxiliary steam set-up is adequate to maintain or provide auxiliary steam requirements.

5) Other Auxiliaries

G - 1 HP heater #5 is isolated. Many tubes of B Heat Exchanger are plugged.

S - 1 Excessive vibration at the circulating water pump causing one-sided condenser operation.

S - 2 One(1) full capacity condensate pump cannot deliver required capacity beyond 250 MW due to clogging of the suction strainer. Full capacity of the condensate pumps should be used effectively.

Pressure drop across the suction strainers, drain coolers, LP heaters and demineralizers must be closely observed.

HP Heater #6B replaced by straight pipe.

<u>M - 1</u> High percentage of tube leaks at HP heater #5A and #5B. HP heater #5A is isolated. Install a new heat exchanger.

<u>M - 2</u> Frequent failure of main condenser tubes (SUS). Many tubes of 2A heat exchanger are plugged.

Fig. 2-1 PRESENT CONDITION OF LP TURBINE

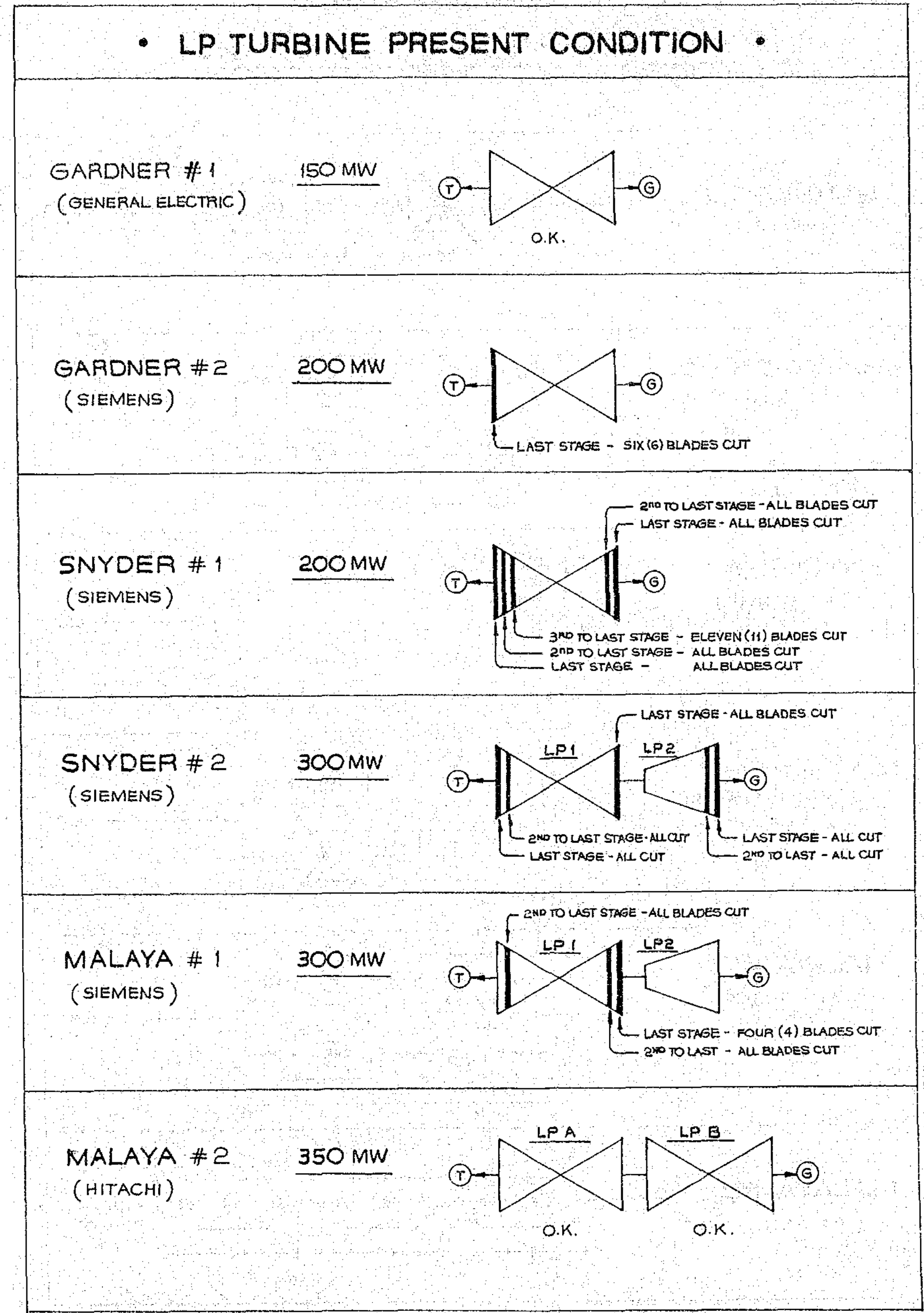
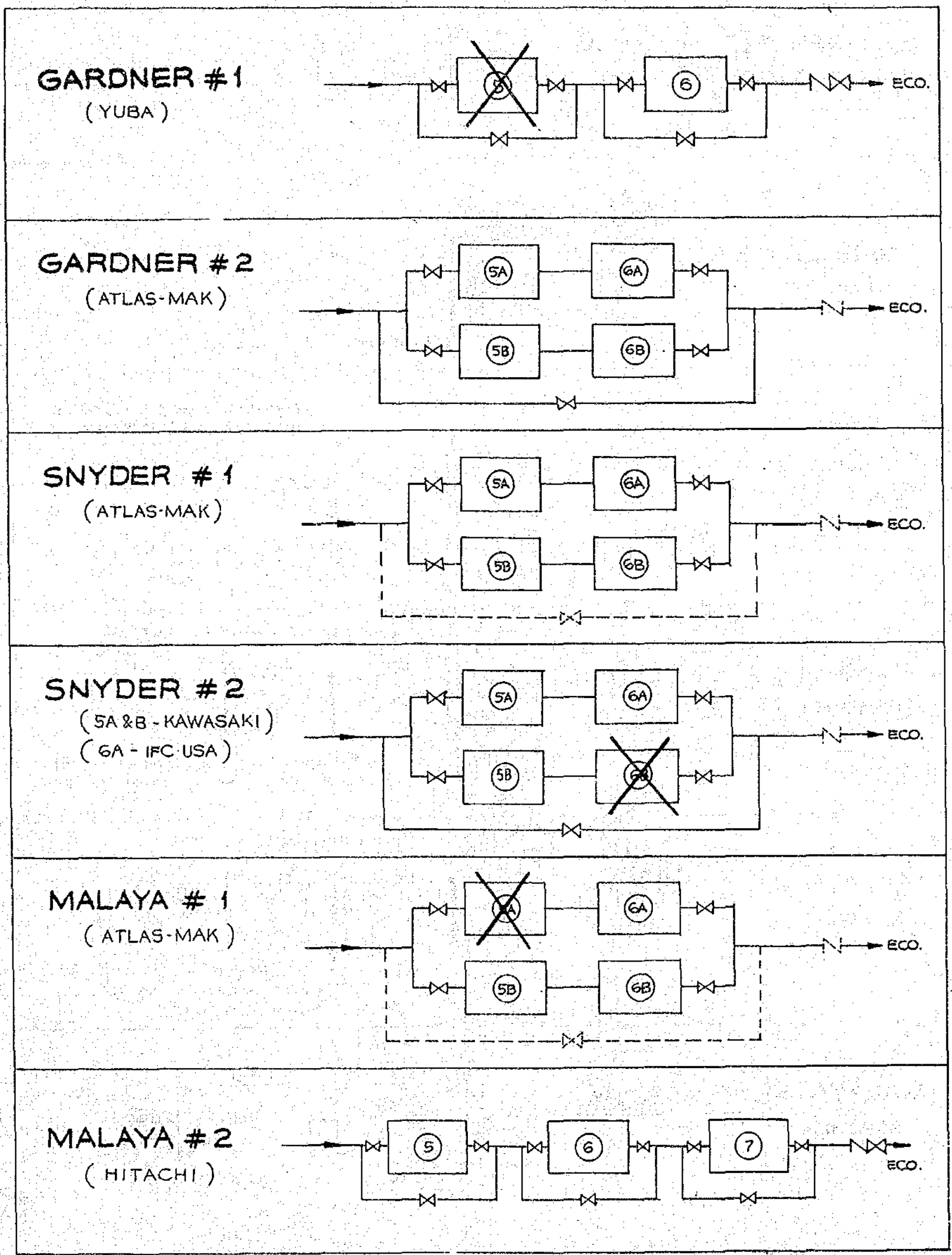


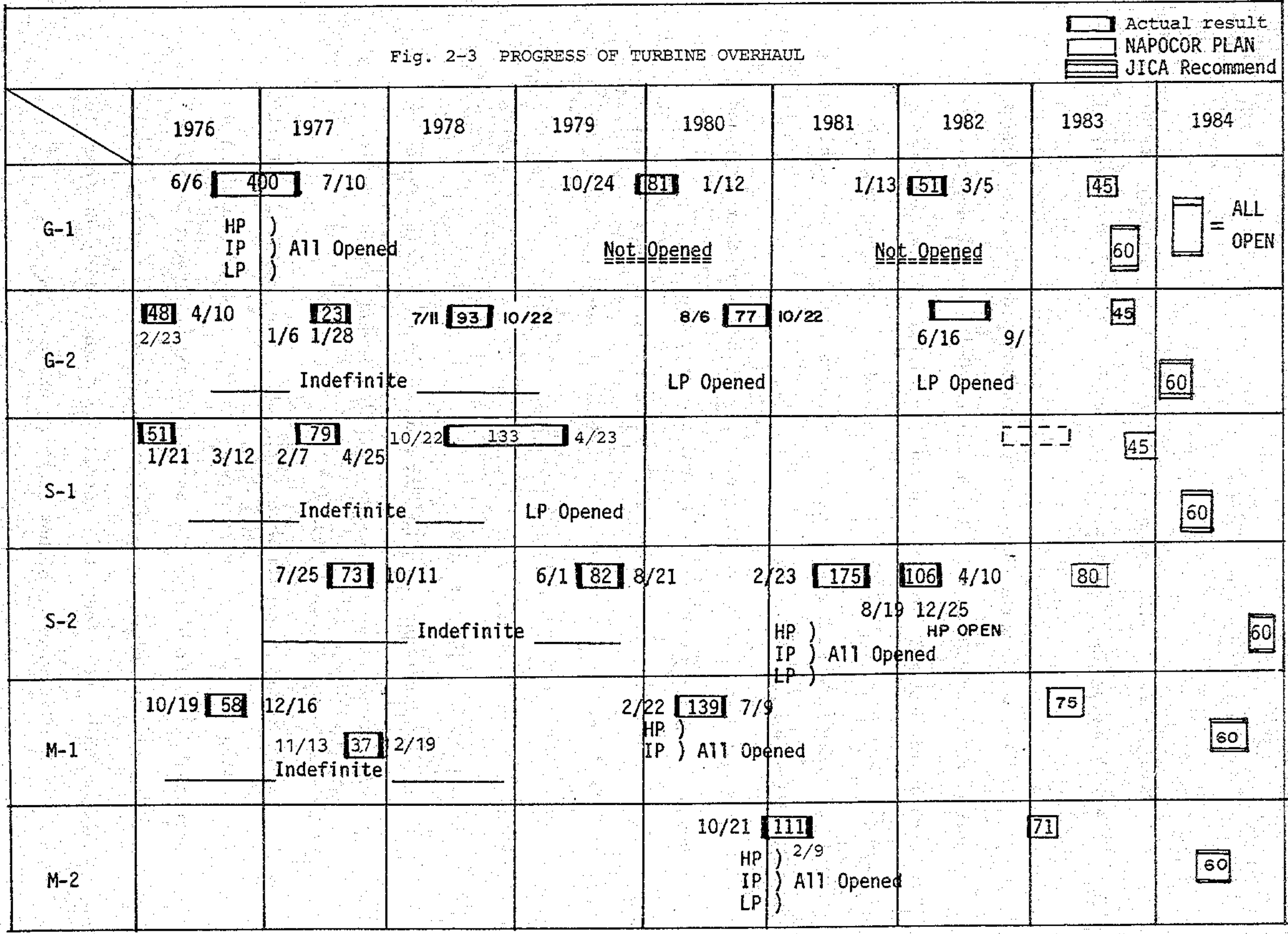
Fig. 2-2 PRESENT CONDITION OF HP HEATERS

HP HEATERS' PRESENT CONDITION



September 25 '82

Fig. 2-3 PROGRESS OF TURBINE OVERHAUL



2.2.6 Generator

Damage due to hot spots was found on the generator stator core end during last overhauling in Snyder-2 (1981) and Malaya-1 (1980).

As very well known that hot spot is initiated during leading power factor operation, Kraftwerk Union (KWU) recommended to increase hydrogen gas pressure and operate within narrow range capability curve in 1979. But this recommendation was not performed immediately because higher seal oil pressure could not be supplied by the original seal oil unit.

After the last overhaul, the H_2 pressure was increased and now is being operated in the recommended pressure.

KWU reported that there will be probably failure on stator coil in future if the generator is left as it is.

This problem was found on M-1 Unit actually in 1980 and already 2 years had past since occurrence of the problem, yet no substantial solution was done.

It is important now to have a policy to initiate quick repair/replacement of the plant system/equipment so as to find a way out of this critical situation.

NAPOCOR had a negotiation with KWU so as to find out the first step of solution, with regard to the matter described in section 5.3.1. "Problem on Hot Spot of Generator Stator Core End."

If NAPOCOR hopes to postpone the repair to future, it is recommendable to study to install some monitoring devices to measure the temperature of hot spots at the core end.

2.2.7 Control and Instrumentation System

1) Automatic Boiler Control

Automatic operation of boiler is being performed only on drum type boiler of Gardner-1 and Malaya-2. As for once through type boilers, almost all have no experience of automatic operation after commissioning due to hunting except Malaya-1 which has experience of automatic operation for a few months after fine tuning/calibration carried out by Siemens Engineer during last annual overhauling. As a result of the survey, the principal causes, which hampers the automatic operation of the boiler are summarized as follows:

a. Control drive units such as valves, vanes and dampers, boiler feedwater pump governing system and EHG system of main turbine have lost their control functions, or have slow response.

Therefore, all of them should be completely overhauled, fine tuned/calibrated and simulated by manufacturer's engineer in order to have good response.

b. Signal transmitter and controller such as temperature, pressure, flow, level, etc. have already lost their functions, or have slow response, some of them are still being defective, or removed due to no spare parts available. These should be repaired or replaced and calibrated completely.

c. Power plant major equipment are now under insufficient conditions such that some of low pressure turbine blades were broken and cut, some boilers are being operated in reduced pressure operation, air preheaters are being clogged, feedwater heaters are defective and many condenser tubes are plugged.

These conditions cause difficulties of automatic operation because feed forward signals are much different from actual operating condition. Static characteristic of controlled equipment is very important in case of once-through boiler control.

These equipment should be rehabilitated to original condition for easy control and to have more output and higher availability.

NAPOCOR should request for manufacturer of control equipments to submit the record of tuning/adjustment during overhaul and corrective advice, furthermore training of NAPOCOR personnels.

2) Local Control and Local Instruments

Almost all local control equipment are defective or still being removed. These equipments seemed to be trivial problem. But these equipments support plant operation, performance and availability. Please note that these equipments should be fixed or replaced immediately in order to have reliable service.

3) Replacement of Automatic Boiler Control System

Replacement of automatic boiler and start-up by-pass system with a digital control system for Snyder-2 is now under planning and design process by NAPOCOR.

Also in Japan, the replacement of almost all automatic controllers has been experienced due to non-replenishment of spare parts, however, prior to implementation of replacement of all system parts, the following items are inevitable to have successful operation of new system.

a. To perform the item mentioned in 1) a to c and 2) of this subsection.

b. To improve environmental condition of relay room, control room and local place.

c. To install constant voltage constant frequency power supply unit in order to supply new control system with stable power.

2.2.8 Chemical Management

Gardner/Snyder and Malaya Thermal Plants are being operated with boiler feed water quality over the allowable limit. This is caused by frequent condenser leakage, improper operation and regeneration of condensate polishers. Condenser leakage problem is common to all units especially Malaya-2 which experiences frequent condenser leakage. During condenser leakage, the detection method being used is just by analysis. The detection limit of the chloride analysis was found to be 0.1 ppm. Based on the graph, the equivalent conductivity of 0.1 ppm chloride after cation resin is 1.2 micro S/cm. Below 0.1 ppm chloride could no longer be detected. Therefore, the reading of "0" chloride inthe log sheet indicated a true value of below 0.1 ppm chloride. The limit value of conductivity of the feedwater is 0.3 micro S/cm.

The condensate polishers are being operated NH_3 type so that it will not produce good water quality in case of condenser leakage. Likewise, JICA team observed that the effluent of condensate polishers indicates presence of contaminants. This might be due to ion exchange unbalance and the quality of regenerant chemicals. It was observed that the caustic soda being used in the regeneration of condensate polishers resin contained high percentage of sodium chloride and silica. Its presence will greatly affect the quality of effluent of condensate polishers. In Snyder-1, two condensate polishers were tested operating it H-OH type. The first one indicated an effluent conductivity of 0.19 micro S/cm while the second one has a conductivity of 0.5 micro S/cm. The latter's conductivity is high and might be due to improper regeneration and resin unbalance. JICA team recommends that the condensate polishers will be operated H-OH type in order to produce good water quality. Operating it H-OH type will cause problem in the supply of demineralized water since the thermal plant's water inventory is always low due to frequent start-up and condenser leakage. With the above problem, JICA team is recommending that the condensate polishers be operated H-OH type at least during unit start-up and condenser leakage. If the regeneration frequency of the condensate polishers is increased it will cause deterioration of the resin. In addition, Gardner-2 condensate polisher has no regeneration facilities yet.

The demineralizing plant and condensate polishers are manually operated (regeneration and servicing). The monitoring system of the equipment are all not working. Conductivity monitor and flow meter should be repaired.

The problem of supply of demineralized water is common to both thermal plants. Additional demineralizing plant will be installed at GSTP. MTP always experiences condenser leakage. Due to lack of demineralized water, boiler blowdown is limited. The condensate polishers also need demineralized water in their regeneration. If the frequency of regeneration increases, there will be problem on the supply of demineralized water. In this regard, additional demineralizing plant is needed at MTP. Likewise, MTP has also a problem on raw water supply to demineralizing plant due to lowering of the water table of the deep well causing the reduction of the production. JICA team recommends that the

Laguna Lake water should be utilized as make-up to the demineralizing plant after undergoing pre-treatment and passing through reverse osmosis.

The present thermal plant chemical management is being entrusted to the chemical section of the plant. The water quality and deterioration data are not being evaluated by the plant management. The exchange of information or discussion of new technique/data between the different chemical sections is seldom done. JICA team recommends creation of central laboratory to supervise the chemical management of all NAPOCOR chemical laboratories. The said laboratory will handle the different problems encountered by the thermal, geothermal and nuclear power plants. Initially, JICA team recommends 5 - 7 staff members to supervise the chemical management of MMRC thermal plants. In the new future, if the scope of work includes geothermal, nuclear plants and other NAPOCOR plants, the staff should be increased to 20 members. The scope of work includes special water analysis, material corrosion and control analysis and environmental pollution control.

2.2.9 Station Electrical System

Power plant electrical systems are composed of 4160 V metal-clad switchgear and 480 V switchgear and motor control center and these equipment are located far apart inside the power house. Especially there are plenty of leaks at roof drains and underground pipings, and this will cause submersion of control centers and ultimately grounding of electrical parts and wirings.

These matters should be improved first. Dirtiness in the switchgear and motor control center was noted and it seemed that less maintenance was given to these equipment.

As for the spare control center unit, some parts were being removed, which are supposed to be put in complete condition so as to be used when other unit being used fails. It is requested therefore, to perform routine cleaning surrounding the area of electrical facilities and overhaul of all switchgears and motor control centers during annual shutdown.

2.2.10 Associated Substation and Transmission Line

Thermal plants are connected to 115 kV substation which belongs to MERALCO and 230 kV substation by Northern Luzon Regional Center (NLRC) of NAPOCOR. Therefore, tight connection should be taken for the maintenance and operation such that there should be no double shutdown when maintenance works are required.

When the balance of supply and demand collapsed due to some accidental shutdown, load shedding should be rapidly performed first in order to prevent frequency drop at power plant. Breakdown of low pressure turbine blades due to low frequency operation will take longer power interruption.

According to the past record of tripping and tripping encountered actually, there seems to have insufficient coordination between settings of power plant relay and transmission line relay. These must be improved immediately.

2.3 OPERATION AND MAINTENANCE

2.3.1 Operation

It would be understood that the operations are trying their maximum effort in order to ensure the plant output inspite of automatic boiler control and almost all of local controls which are not put into automatic operation. But these control equipments are indispensable for safe and efficient operation. Also some important monitoring instruments such as flue gas O_2, boiler metal temperature and feed water conductivity are defect. Without these control equipments and monitoring instruments, reliability of thermal power plant cannot be expected. Immediate repair and operation with assistance of these equipments are desirable.

There is quick/proper activity during start-up or accidental shutdown but there is lacking correct attitude of operator to investigate the cause of failure.

There may be also lacking for identification to the limited value for each equipment under operation. Especially, S-2 unit and M-1 unit in which there are hot spot problem on the generator core end so that operators should pay attention to power factor, hydrogen pressure, hydrogen purity, cooling water temperature which must always be maintained within the allowable limit. Together with actual action, fundamental knowledge, capability of investigation and attitude should be promoted for operators.

Vigorous execution of routine test, patrol check, to follow the standard procedure strictly and to complete the check sheet system should be carried out and improved continuously. (Refer to Appendix-3)

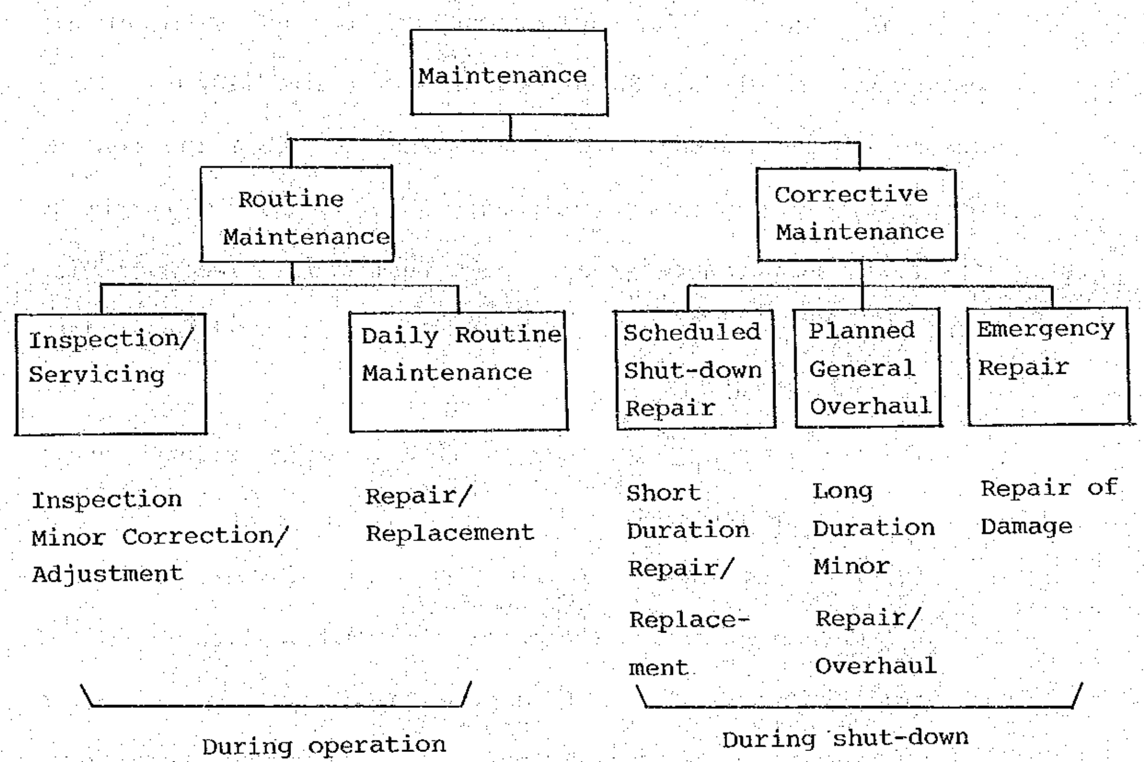
In central control rooms, principal flow diagrams, sequence diagrams and standard operating procedures should be arranged. during start up and/or shutdown, operators can ensure whether their operation are correct by Standard Operation Procedure (SOP). There were many tripping accidents due to uncontrollable temperature of boiler steam. It seems these accidents came from over-feeding of fuel oil. Following standard procedures, operator can avoid these misoperation. For this purpose, SOP must be described with numerical figure, for example fuel oil quantity, valve opening, etc. Also drawings are useful for trouble shooting and correct operation.

2.3.2 Maintenance

1) Preventive Maintenance

NAPOCOR has the general concept of maintenance illustrated in Fig. 2-4.

Fig. 2-4 CONCEPT OF MAINTENANCE



There are two (2) kinds of maintenance, namely preventive maintenance, during operation, performed jointly by the operation and maintenance staff, and corrective maintenance during shutdown.

In Japan and also other countries, preventive maintenance is considered as opposite term for break down maintenance. The former is to maintain not so as to break during usage, the latter to repair after breakdown. So, in this meaning, even annual overhaul is considered as preventive maintenance. In the case of break down maintenance, there might be large damages on the equipments and demerit compared to preventive maintenance in the long run. Especially, in thermal power stations, preventive maintenance in the wide sense is necessary when high availability is expected.

2) Daily Maintenance

JICA team carried out a study of the condition of all equipments at Gardner/Snyder and Malaya Thermal Plants. As a result of this study, JICA team found out that the routine maintenance job for each equipment is not being carried out by the plant maintenance group. JICA team would like to advice NAPOCOR to carry out a routine maintenance for each equipment.

a. Existing Condition

(a) All rotating machineries (fans, pumps, motors, etc.) are becoming dirty.

(b) There are plenty of dust or pieces of heat insulating materials around these rotating machineries.

(c) There are plenty of damaged indicators (pressure or temperature gauges) or indicators with inefficient calibration to confirm their true value.

(d) All instruments control devices (controllers, control valve positioner, etc.) are becoming dirty.

(e) There are plenty of dust around the Control Center, Power Center and Metal-clad switchgear.

(f) Flue gas is very prominent in the main powerhouse building.

(g) When it rains, there are plenty of roof leakages such that equipments are corroded by sulfation of rain-water.

b. Recommendation

All rotating machineries or instrument devices of the thermal plants must be free from dust or foreign matters. This could only be carried out by conducting a daily preventive maintenance. Therefore, a routine preventive maintenance must be carried out for all equipment to improve their efficiency.

In Japan, our maintenance groups are conducting routine maintenance jobs as shown in Appendix-2. JICA team would like to advice NAPOCOR to adopt and implement the routine maintenance works in Appendix-2.

c. Countermeasure for Preventive Maintenance

(a) Should NAPOCOR consider to adopt JICA team's recommended preventive maintenance schedule as per Appendix-2, NAPOCOR's existing equipment problems may be minimized. If during the preventive maintenance inspection parts were found to wear out, then try to replace them if spare parts are on hand, or if none, prepare an immediate purchase order for these spare parts. Worn-out parts must be scheduled for replacement before the equipment breaks down.

(b) If during normal operation some abnormal conditions were observed, immediately prepare the planning of the job as to duration of the job, required manpower for the job, the necessary tools and the spare parts needed (if available). The job planning could also be adopted if the NAPOCOR found parts starting to wear out during NAPOCOR's preventive maintenance inspection. According to extent/kind of accidents, NAPOCOR should not hesitate to shutdown unit. Only few days operation under abnormal condition sometimes results big damages to need long time and big cost for repair.

(c) JICA team had a chance to read NAPOCOR's "Preventive Maintenance System and Procedure". This report is a remarkable program and JICA team is expecting that NAPOCOR's various maintenance groups of each thermal plant will carry out this program. The result of JICA team study on NAPOCOR's various equipments at the site showed that if NAPOCOR carried out preventive maintenance jobs as per Appendix-2, for instruments and control, NAPOCOR could avoid plenty of instruments troubles caused by inadequate maintenance. Therefore, JICA team hereby recommends that the Instruments and Control group adopt and carry out JICA team's recommendations as per Appendix-2.

3) Overhauling

Boiler, turbine and their auxiliary equipments are always operated on merciless terms, such as being exposed to high temperature or high pressure steam, and/or flue gas. Therefore these equipments must be carried out by sufficient periodical overhaul to improve the reliability of the thermal power plants.

In case of Japan, a thermal power plant is under strict obligation to do a periodical overhaul. Steam turbine is overhauled every two (2) years, the other equipment, every year.

In case of NAPOCOR, this periodical overhaul of each thermal power station is not carried out as planned. Hence, the reliability of these thermal power stations decreases, and some of the equipments in a thermal power station are increasing their damage. These effects are getting bigger, and they shorten the equipments service life, for example, boiler tubes, AH elements, turbine proper, condenser tubes and feedwater heaters, etc.

Therefore, it is necessary to avoid the deferment for the periodical overhaul of the unit. And also the periodical overhaul of a thermal power station should be carried out according to the program which was planned before hand, and the periodical overhaul should be finished within the schedule. For this reason, the schedule of periodical overhaul should be correctly planned by System Operation Division (S.O.D.).

In the thermal power station side, maintenance division should plan correct schedule of the periodical overhaul and all of the group concerned, such as plant maintenance group, technical service group, CMD, QA Group, P&P Group, manufacturers, and subcontractors, etc, should cooperate to finish within schedule as possible.

In case of Japan, we use Critical Path Method (C.P.M.) to plan the correct schedule of the periodical overhaul as shown in Appendix-6.

Table 2-4 shows the number of days required for overhaul, that has been considered as standard in Japan.

Year		1	2	3	4	5	
Kind		B-T	B	Semi B-T	B	B-T	Repeated
Standard Number of Days	Class 250 MW	40-50	19-23	27-35	19-23	40-50	- " -
	Class 350 MW	43-55	20-29	29-36	20-29	43-55	- " -

Table 2-4 STANDARD NUMBER OF DAYS FOR OVERHAUL

Note B-T : Boiler & Turbine Thorough Inspection Turbine Rotor Taken-out

Semi B-T: Boiler & Turbine Simplified Inspection Turbine Upper Casing Removed

B : Only Boiler Inspection & Deferred Jobs

This is the case of no particular major repair/replacement works needed.

No sooner than the start of overhaul, all damages which have taken place during operation of past one (1) year must be checked in the process of analyzing main points in every equipment. Check the extent of damages, keeping necessary record and replanning repair schedule and executing such repair work shall be performed. The person in charge should be responsible for correctness and perfectness of the repair works.

4) Maintenance at Emergency Shutdown

There might be many works to e done but left without repair because of unit running. At the time of shutdown due to some trouble, those other secondary jobs are able to be done besides the prime restoration work, taking advantages of the term of such main work. In the case such secondary works shall be not the ones based on a sudden idea, but the very ones well prepared before hand. Moreover at the opportunity, other equipments shall be also checked and immediate repair should be made when abnormalities are observed.

Through such precise maintenance, conditions of equipments will be maintained so that continuous operation might be expected.

5) Record of Maintenance

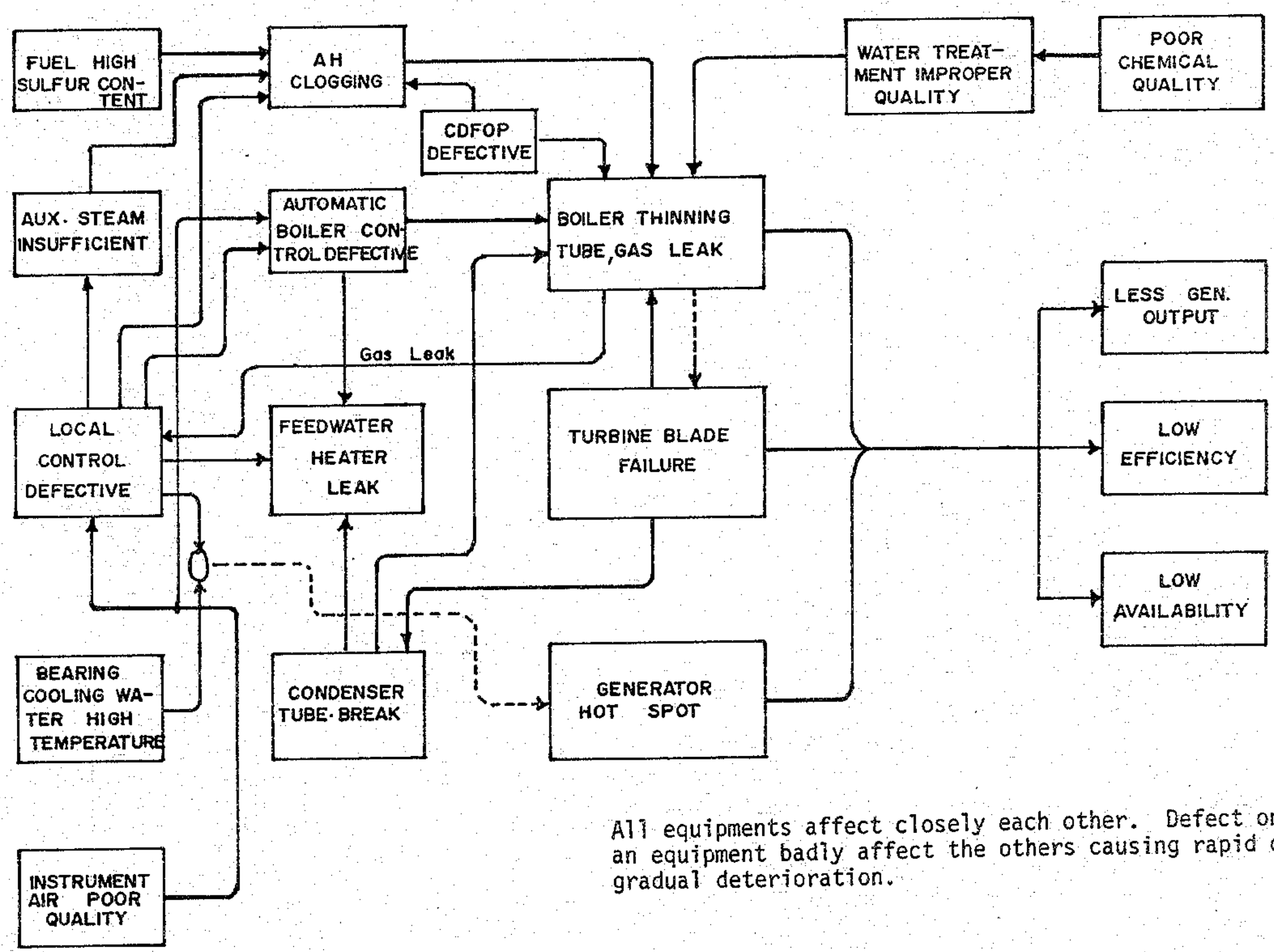
It is very important and useful for plan and execution of maintenance to establish the historical data on every equipment. Study Team designed equipment record cards for all equipments. This card contains all important data pertinent to the equipment and is described whenever major repair/overhaul are implemented. Preparation of cards of all equipments at same time is bulk job, so presently it is advisable to prepare cards for some major equipments.

Anyhow immediate description of maintenance record is necessary after repair works.

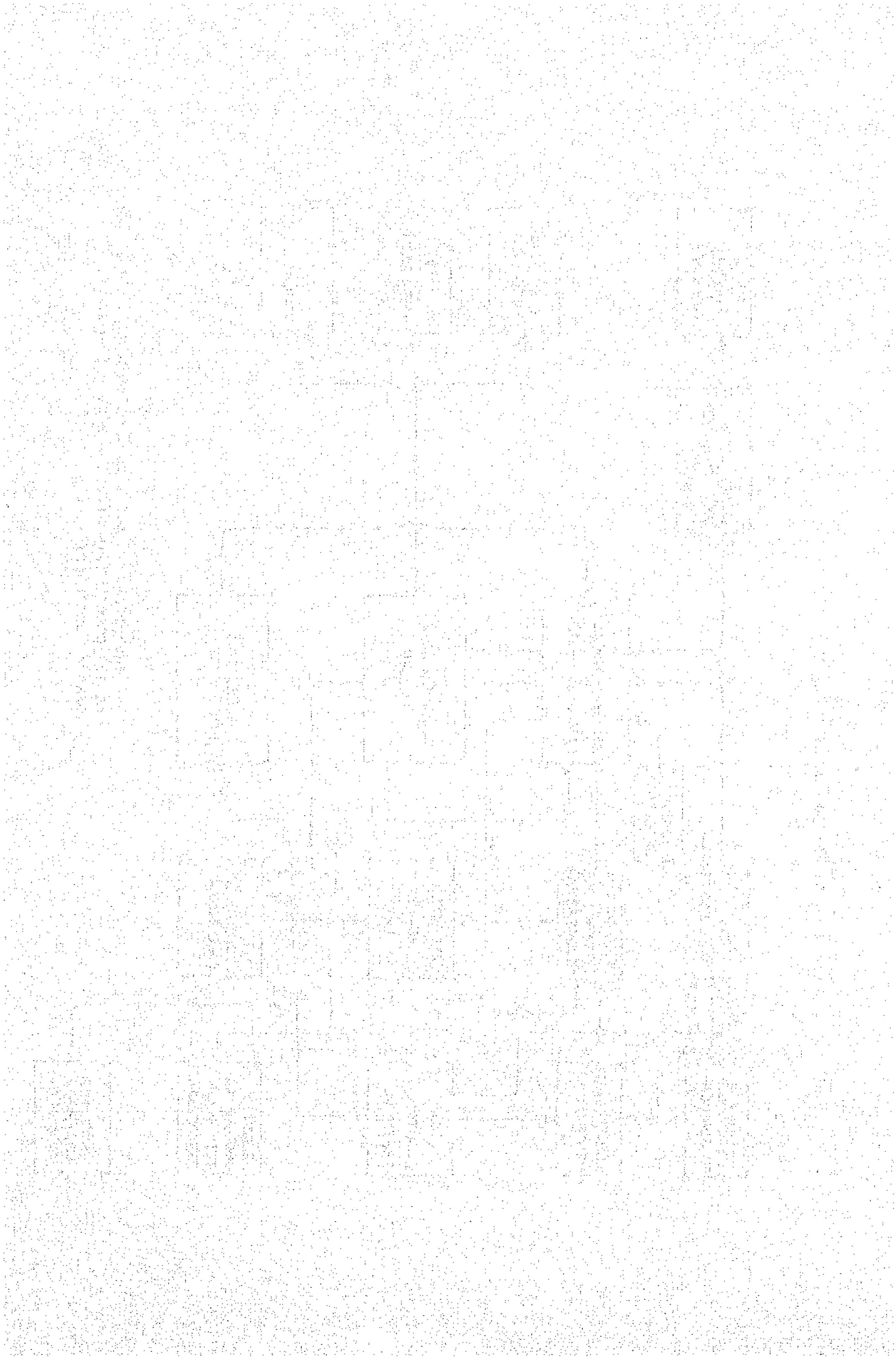
Records for overhaul and long term repair are prepared by QA Group nowadays and those are very useful for planning/review of maintenance. It is desirable that these overhauling activities are recorded and kept for easy reference of preventive maintenance from now on.

Spare parts list should be prepared and recorded at the time of every store/use and number of spare parts stored must be clarified and identified. Maximum and minimum number of every spare part in store are predetermined and after spare parts are decreased to minimum number, immediate purchase requirement and supplement are necessary.

Fig. 2-5 DETERIORATION FLOW CHART



All equipments affect closely each other. Defect on an equipment badly affect the others causing rapid or gradual deterioration.



3. POWER SUPPLY SITUATIONS

3

3. POWER SUPPLY SITUATIONS

3.1 PRESENT SITUATION OF ELECTRIC POWER SUPPLY IN LUZON

3.1.1 Generation

As of the end of 1981, the total capacity of the generating plants in Luzon Grid is 3224 MW excluding small capacity generators supporting local loads. This total installed capacity is made up of hydro 554 MW (17%), geothermal 440MW (14%) and oil thermal 2230 MW (69%). Most of the hydro power stations are located in the north of Manila, geothermal power stations in the south and oil-fired power stations in and around Manila. The main technical data of the existing power stations in the Luzon Grid are presented on Table 3-1 (Existing Power Stations in the Luzon Grid) and their locations are shown in Fig. 3-1, Luzon Grid Power Stations.

TABLE 3-1 EXISTING POWER STATIONS

		MW		As of Year End 1981
HYDRO	Ambuklao	75	554	
	Binga	100		
	Angat	218		
	Pantabangan	100		
	Caliraya	32		
	Botocan	17		
	Masiway	12		
	Kalayaan	(300)		1982
	Magat	(360)		1983
	San Roque H.E.	(390)		1990
GEOTHERMAL	Tiwi 1 - 4	220	440	
	Mak-Ban 1 - 4	220		
	Tiwi 5	(55)		1982
	Tiwi 6	(55)		1982
	Mak-Ban 5, 6	(110)		1984
	Tiwi 7, 8	(110)		1986
	Tongonan	(440)		1986
THERMAL	Battan 1	75	2230	
	Battan 2	150		
	Malaya 1	300		
	Malaya 2	350		
	Snyder 1	200		
	Snyder 2	300		
	Gardner 1	150		
	Gardner 2	200		
	Tegen 1	100		
	Tegen 2	100		
	Rockwell 1 - 5	125		
	Rockwell 6 - 8	180		
	Coal Ther. 1	(300)		1985
	Coal Ther. 2	(620)		1988
NUCLEAR	PNPP	(620)		1985

(   ) - Under planning or construction

Fig. 3–1 LUZON GRID POWER STATIONS