Limit Value on Water Quality

G-1

BOILER WATER LIMITS

PRESSURE = 1800 psig

Sodium Chloride	10 ppm or less
Soluble Phosphate (following 2.6 Na-PO_4 mole ratio)	2 to 4 ppm as PO_4
Silica, SiO_2	0.5 ppm or less
Total Solids	100 ppm or less
pH	8.9 - 9.25 corresponding to 2-4 ppm PO_4

FEEDWATER

pH	8.6 to 8.9
Dissolved Oxygen	0.007 ppm or less
Copper, Cu	0.01 ppm or less
Iron, Fe	0.02 ppm or less
Hydrazine, N_2H_4	0.01 - 0.07 ppm
Hardness as $CaCO_3$	0

G-2, S-1, S-2, M-1

MAIN STEAM AND CONDENSATE (SIEMENS)

	START-UP	NORMAL
Silica, SiO_2	50 ppb or less	20 ppb or less
Total Iron, Fe	50 ppb or less	20 ppb or less
Total Copper, Cu	10 ppb or less	3 ppb or less
Sodium & Potassium, Na^+ and K^+	20 ppb or less	10 ppb or less
Conductivity (after passing thru cation resin)	0.5 m mho/cm equal or less	0.3 m mho/cm equal or less

ECONOMIZER INLET (HITACHI) NORMAL OPERATION

pH	9.2 - 9.4
Dissolved Oxygen	7 ppb (max.)
Silica, SiO_2	20 ppb (max.)
Hydrazine, N_2H_4	10 - 70 ppb
Total dissolved Solids	50 ppb
Copper, Cu	2 ppb
Total Iron, Fe	10 ppb
Conductivity	0.3 m mho/cm (after passing thru cation resin)

M-2

FEEDWATER

Dissolved Oxygen	Preferably zero, and not over 0.007 ppm
Hydrogen Ion Valve (pH) (85°C)	Between 8.6 and 8.9 for high pressure feedwater heater constructed from copper alloy tubes, and between 9.2 and 9.4 for feedwater heater constructed from steel tubes
Hardness as $CaCO_3$	Zero
Total Copper, Cu	0.005 ppm or less
Total Iron, Fe	0.01 ppm or less
Oil	Preferably zero
Hydrazine (N_2H_4)	Between 0.01 and 0.03 ppm
Conductivity (25°C)	less than 0.3 ppm

BOILER WATER

Hydrogen Ion Valve (pH)	Between 9.5 and 10
Total Solids	Less than 220 ppm
Phosphoric acid (POa_3)	Between 1 and 3 ppm
Sulfurous acid Ion (SO_3^2)	Preferably less than 0.3 ppm

2) Daily water quality management

Limits of water quality of GSTP, MTP are approximately the same as those in Japan.

Abaltsis of water quality is made at intervals of 6 hours in every item and 1 hour in demineralizing plant. The analysis value of each item is within the limit value as shown in Table X-XX.

The measurement of dissolved oxygen is made less frequently, there exists no past record on this at GSTP. Conductivity of condensate water, feedwater, boiler saline and steam are analyzed less frequently too. Water quality is measured by ASTM method, and is almost the same method as JIS (Japanese Industrial Standard). JICA team observed the analysis of chloride and silica and confirmed that the skill was adequate enough.

Volume of chemicals used for water treatment is measured daily and volume of NH_4OH is not measured.

Measuring Method of Water Quality

Items	Measuring Method
pH	Direct measurement of pH by Beckman Zeromatic IV
Conductivity	Direct measurement of conductivity by VSI Model 31 Conductivity Bridge
Turbidity	Direct measurement of Turbidity by Fisher Electrophotometer II
SiO_2	ASTM D 859-64 T referee Method B
SO_4	ASTM D 516-63 T Non-Referee Method A
M Alkalinity	Titration with 0.02N Sulfuric Acid following same procedure as in ASTM D 1067-64 Non-Referee Method A
Cl	ASTM D 512-62 T Referee Method C
Total Hardness	ASTM D 1126-65 Non-Referee Method
Dissolved Oxygen	D 888-66 Referee Method A
Fe	D 1068-62 T Referee Method B
Cu	D 1688-63 T Referee Method B
NH_4	D 1426-58 (1965) Referee Method-Colorimeteric Determination
N_2H_4	D 1385-64

TABLE 2-2 ACTUAL WATER QUALITY

Raw Water

W A T E R   Q U A L I T Y

	Date	pH	MS/CM	Turbi ppm	SiO_2 ppm	Sa ppm	M.VAL. $CaCO_3$ ppm	Cl ppm	Hard-ness ppm	Total solid ppm
GSTP										
Raw water (RO inlet)	4/23	6.9	1200	-	70	52	95	133	30	245
R.O. Brine	4/23	6.8	2300	-	100	150	156	273	60	495
R.O. Outlet	4/34	5.6	110	-	23	0	22	38	0	54
MTP										
Filtrared Water	5/18	7.0	-	0.01	85	6	307	107	44	-

Make-up Water & Secondary Treatment (GSTP)

	Date	pH	MS/CM	Turbi ppm	SiO_2 ppm	Sa ppm	M.VAL. $CaCO_3$ ppm	Cl ppm	Hard-ness ppm	Total solid ppm
Gardner Demineralized water										
Anion Outlet	5/12		10			20				
MB Outlet	5/12		0.5			10				
Storage TU	5/18		0.8			6				
G-1										
CP Outlet	5/12	8.9				9	5	0		
Eco. Inlet	5/12	8.9				9	5	0	39	
Boiler Saline	5/12	9.0				480				0
SH Outlet	5/12	8.9				9	5	0		
G-2										
CP Outlet	5/12	9.2				7	5	0		
Con Demi Outlet	5/12	8.5				6	5	0		
Eco. Inlet	5/12	9.3				7	5	0	63	
SH Outlet	5/12	9.2				6	5	0		
Snyder Demineralized Water										
Anion Outlet	5/12		10			20	-			
MB Outlet	5/12		0.5			8				
Storage Tank	5/18		0.8			7				

	Date	pH	MS/CM	Turbi ppm	SiO_2 ppm	Sa ppm	M.VAL. $CaCO_3$ ppm	Cl ppm	Hard-ness ppm	Total solid ppm
S-1										
CP Outlet	5/12	9.2				7	5	0		
Con Demi Outlet	5/12	8.5				6	5	0		
Eco Inlet	5/12	9.3				7	5	0	32	
SH Outlet	5/12	9.3				6	5	0		
S-2										
CP Outlet	5/12	9.2				7	5	0		
Con Demi Outlet	5/12	9.2				6	5	0		
Eco Outlet	5/12	9.3				7	5	0	31	
SH Outlet	5/12	9.3				6	5	0		

Make-up Water & Secondary Treatment (MTP)

W A T E R Q U A L I T Y

	Date	pH	MS/CM	MS/CM Cation pass	O_2 ppb	SiO_2 ppb	Fe ppb	Ca ppb	N_2H_4 ppb	Cl ppb
MALAYA Demineralized Water										
Anion Outlet	5/12		4.5			10				
MB Outlet	5/18		0.3			5				
Storage Tank	5/18		0.6			5				
M-1										
CP Outlet	5/18	8.5		0.19		9	5		15	
	5/18	9.2-								
Den Inlet		9.4				8	5		30	
Eco Inlet	5/18			0.2	7	8	5		30	
SH Outlet	5/18	9.2		0.2			3	0		
M-2										
CP Outlet	5/18	9.0	1.3			10				
Den Inlet	5/18	9.2			0					
Eco Inlet	5/18	9.3	1.5			10	5	0	30	
Boiler Saline	5/18									
SH Outlet	5/18		1.0			10				

3) Fuel analysis

Fuel analysis is done once a day for the following items:

Specific weight, Viscosity, Sulfur content and calorific value

The fuel oil line is common to each boiler of power plant.

Since sulfur content in fuel oil used in power plant is 2.5 - 4.5%, injection of additives into fuel oil has been considered but now it is not carried out.

4) Chemical laboratory

Chemical laboratory of Gardner/Snyder Thermal Power Plant is located one floor below the turbine hall while that of Malaya Thermal Power Plant is located at the same floor of the turbine.

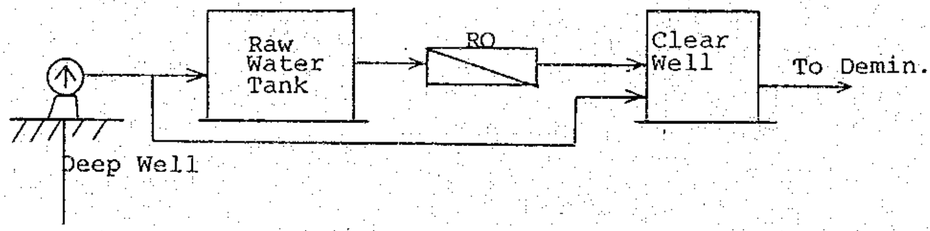
5) Water treatment plant

a) Make-up water treatment

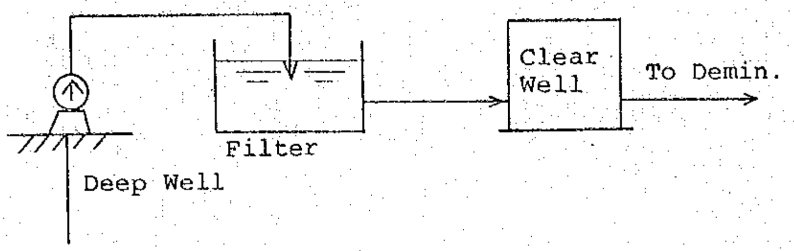
Raw water is supplied from deep well (approximately 300 meters in depth). Raw water is demineralized by reverse osmosis (RO), and transmitted to purifier in Gardner/Snyder Thermal Power Plant, on the other hand, the raw water is filtered by filter and transmitted to purifier. At present, RO equipment is under repair in Gardner/Snyder Thermal Power Plant and the raw water treated with one-sided operation.

FIGURE 2-17 RAW WATER TREATMENT SYSTEMS

Gardner and Snyder Power Plant



Malaya Power Plant



Operation and regeneration of demineralizing plant is manually being done by chemical staff because the instrument for automatic operation is not functioning. The designed capacity of cation and anion exchangers in regeneration are 90,500 gals. and 71,000 gals., respectively. But the actual capacity is below the designed one due to the increase in mineral contents of the raw water.

During the regeneration of cation and anion exchangers, there are no means to determine the operating and backwashing level of resins because of the absence of sight glasses. The completion of regeneration process and service run is determined by actual analysis of the effluent due to non-functioning of the conductivity instruments.

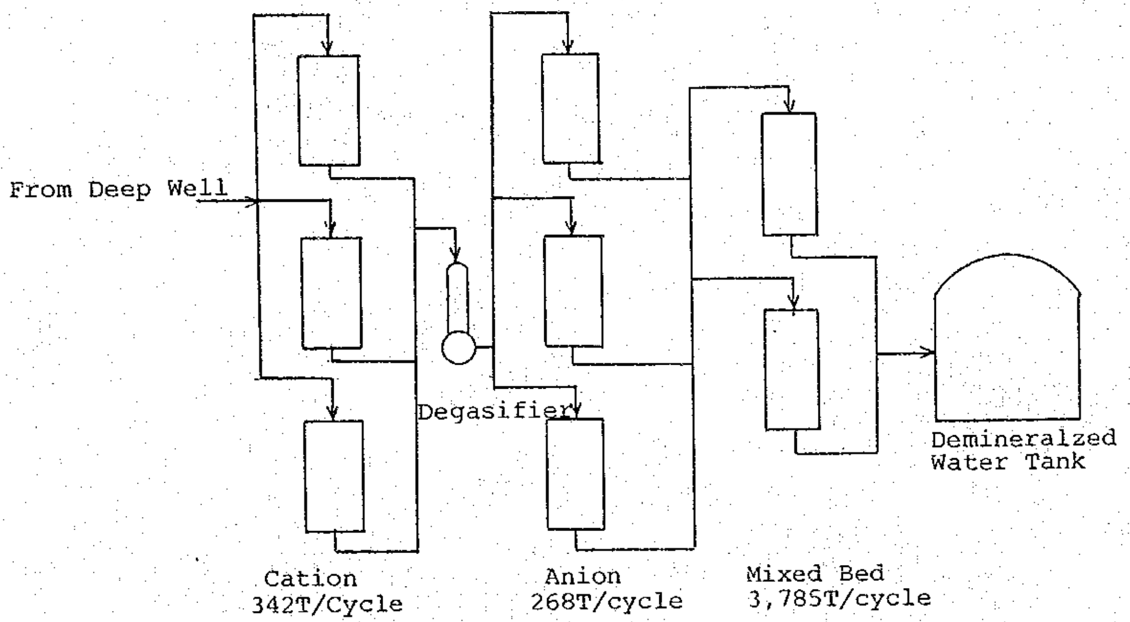
Gardner/Snyder Thermal Power Plant, due to frequent unit start-ups, consumed large volume of demineralized water, thus causing the reduction of the plant demineralized water inventory. To cope with the consumption, demineralized water is transported with the aid of tank truck from Tegen (about 30 kms. distant from Gardner/Snyder Thermal Power Plant), Malaya (80 km) and Bataan (150 km).

Gardner/Snyder Thermal Power Plant now is planning to purchase an additional demineralizing plant to eliminate the hauling of demineralized water.

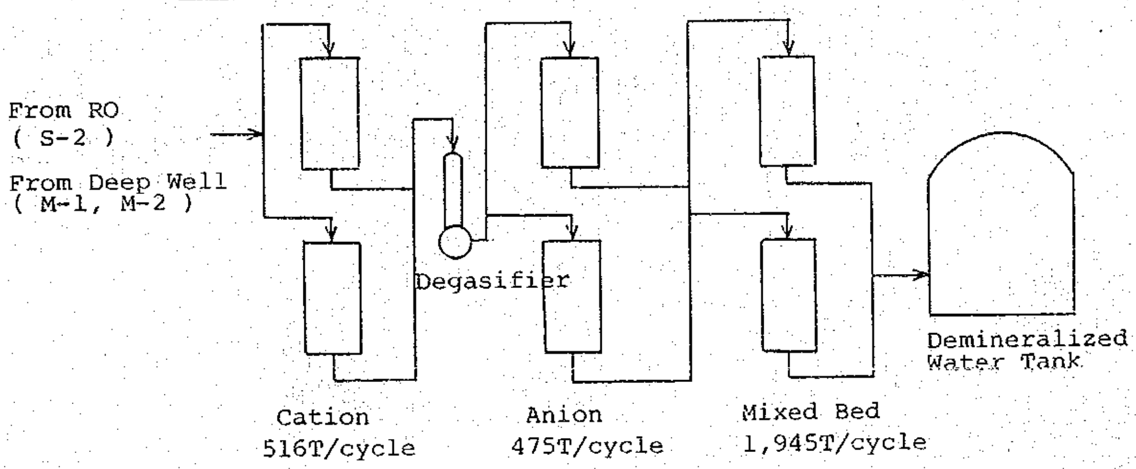
The raw water IN Gardner/Snyder Thermal Power Plant contains high mineral concentration, but 90% of the minerals are removed by RO equipment before the demineralizing plant.

FIGURE 2-18 DEMINERALIZING WATER PLANT FLOW DIAGRAM

G-1, G-2, S-1



S-2 (M-1, M-2 same flow)



b) Secondary feedwater treatment

The secondary feedwater treatment for the once-through boiler is treated with volatile chemicals such as hydrazine and ammonium hydroxide while that for drum type boilers is treated with hydrazine, morpholine and trisodium and disodium phosphates. The said treatment is recommended by the boiler manufacturer. Units of Malaya Thermal Power Plant are the latest among the once-through units installed in the Philippines. The injection of chemical is manually being done. The charging of chemicals are injected manually in proportion to the load. The chemical injection line and tanks are made of carbon steel.

c) Condensate polisher

Condensate polisher operates as a mixed bed, total flow and in ammonia type - condensate polishers in Gardner/Snyder Thermal Power Plant has the same capacity (1,400 GPM, 317 T/H); G-2 has three (3) service vessels, S-1 three service vessels and S-2 four service vessels. On each unit one service vessel is used as a spare. The regeneration of the condensate polishers is done externally. They have one common regeneration facility. In 1982 additional one common regeneration facility was installed at S-2. There were twelve sets of ammonex resins available for condensate polishers. Two (2) sets are of trio-bed type and Ambersep set-up. Trio-bed process is not used in Japan. We had a bad experience on the use of Ambersep process in Japan wherein a difficulty on resin separation was encountered. Inert resin could not completely separate the cation resin. Malaya Thermal Power Plant condensate polishers have the same capacity as those of Gardner/Snyder Thermal Power Plant. They have four (4) service vessels and one (1) reserve resin. They are also externally regenerated.

The designed service resin of each ammonex service vessel is 60 to 65 days but due to the difficulty in resin transferring, the service run is reduced to 30 days.

The ammonex conductivity instruments of Gardner/-Snyder and Malaya are not functioning. In both condensate polishers of thermal power plants, sodium analyzers were installed at their inlet and outlet positions.

JICA team recommends that during start-up and condenser leakages, the ammonex should be operated by HOH type.

In the regeneration process of ammonex resin, the exhausted resin is transferred to the cation regeneration tank in where crude removal and resin separation are done. After complete separation of cation and anion resins, the anion resin is transferred to the anion regeneration tank. After regeneration of the two resins, anion resin is washed with ammonia water for 180 minutes. Then the regenerated resin is transferred to the resin storage tank.

Condensate polishers of Gardner/Snyder and Malaya Thermal Power Plants experienced failure of the under drain system causing clogging of the boiler feed pump strainer. Resin separator of condensate polisher system for Gardner/Snyder Thermal Power Plant was already installed.

The demineralizing plant and condensate polishing system have no indication of flow direction, and color coding and name of pipings.

d) Sampling rack system

Generally, the Gardner/Snyder Thermal Power Plant sampling rack system needs complete rehabilitation. All feedwater quality monitoring instruments associated with it are not functioning, the area around the sampling racks and its vicinity is very

dirty. JICA team could not approach the area because there had been steam leak and the floor was covered with water.

Malaya sampling rack system is better than that of Gardner/Snyder Thermal Power Plant. It needs only some improvements. The rehabilitation plan for Gardner/Snyder Thermal Power Plant sampling rack has been already completed and just waiting for the contractor to render the rehabilitation service.

TABLE 2-3 REHABILITATION PLAN OF SAMPLING RACK AND INSTRUMENT

Sampling Point	G-2, S-1, S-2, M-1			G-1	
	Samp-ling	Conduc-tivity	pH	Samp-ling	Conduc-tivity
Condensate Pump Inlet		0			
Condensate Pump Outlet	0	0		0	0
Deaerator Inlet	0			0	
Economizer Inlet	0	0	0	0	0
Boiler Saline				0	
Waterwall Outlet	0				
Saturate Steam				0	0
Start-up Separation Drain	0				
SH Outlet	0	0		0	0
pH Outlet	0	0		0	
HP Heater Drain	0	0		0	

6) Water quality monitoring instruments

For Gardner/Snyder Thermal Power Plant, only sodium analyzers for feedwater quality monitoring are in operation.

At Malaya Thermal Power Plant, the following monitoring instruments are working.

(1) Sodium analyzer -- installed at the condensate pump discharge and condensate polisher outlet.

(2) Silica analyzer -- installed at the anion outlet and condensate pump discharge of M-1.

(3) Conductivity meter -- installed at anion outlet, condensate pump discharge of M-1 and M-2.

Th conductivity recorder at Malaya demineralizing plant is functioning without chart. Only M-2 has alarm annunciator for high conductivity which is installed in the control room.

7) Condenser cooling water treatment

The cooling water of Tegen condenser is intaked from the Pasig River while the Gardner/Snyder and Malaya utilizes Laguna Lake water. Pasig River has low chloride during rainy season and sea water during summer. The chloride concentration of Laguna Lake water varies from 200 ppm to 600 ppm and the turbidity is about 40 ppm.

The condenser tube of G-1 has a sacrificial zinc anode for the protection of the tube while G-2, S-1, S-2, M-1 and M-2 have the impressed current cathodic protection. The M-1 and M-2 cathodic protection are not working.

Condenser of Tegen Thermal Power Plant is being chlorinated with the use of sodium hypochloride.

M-2 ball cleaning device of the condenser is not working. The condenser is backwashed once a day.

The condenser leak of once-through units were caused mostly by blade failure of the turbine. The damaged blade cut the condenser tubes thus causing leaks to the feedwater system. Likewise, the leak might be due to

erosion of the tube caused by ammonia attack and vibration.

The total number of plugged tube on G-1 condenser is about 10% while those on G-2, S-1 and S-2 ar below 10%. All G-1 condenser tubes were replaced in 1979.
The number of tubes that are plugged on M-1 condenser is about 2.3% on side A and 1.4% on side B. For M-2 condenser, 3.3% is plugged on A-side and B-side is about 1.3%.

TABLE 2-4 COOLING WATER TREATMENT

			Water Quality				
	Material of Cooling Tube	Protect Method	pH	Nacl ppm	Na2SO4 ppm	Hard-ness ppm	Turbi-dity ppm
G-1	Cu-Ni 7 ft/s (2.1m/s)	Sacrifical Anode					
G-2, S-1	Admilalty Metal 6.7 ft/s (2.0 m/s)	Impressed Current Cathodic Protection					
S-2	Almibrass	Ditto	7.1	210	45	80	about 45
M-1	Al-Bronze (Cooling Zone: Cu-Ni 90-10)	Ditto Not working	7.6	630	53	214	
M-2	SUS-316	Ditto Ball Cleaning Not working					
T-1	Cu-Ni	Injection of NaHcl	7.1	330	-	180	-
			7.4	57000		10000	
T-2	SUS-316	Ditto					

8) Disposition of abnormality in feedwater quality

a) Condensate leak

If the chloride concentration is below 2 ppm during condenser leak, the load of the unit is reduced to about 50% so that half of the condenser could be inspected. If the chloride is more than 2 ppm, the unit will be shut down emergently. There were many cases where emergency the unit was shutdown due to high chloride concentration of the condensate.

The condensate polisher should be operated in HO form during condenser leakages. The polisher on service should be replaced with the newly regenerated resin.

Sodium analyzers are now installed at the inlet and outlet of the condensate polisher. In this regard, traces of condenser leakages can easily be detected. Likewise, if there are condenser leakages, sawdust is poured into the tunnel to possibly plug the small leak.

b) Unit start-up

During start-up of once-through and drum type boilers, the feedwater quality limits are the same as those of Japan, respectively.

In our visit to Malaya Thermal Power Plant, JICA team had the experience in observation of the start-up of M-1 unit. In the feedwater analysis of condensate pump discharge, economizer and main steam samples (method of millipore filter membrane was used), Fe contents in the feed water exceeded the limited value considerably.

In the start-up and normal operation of units, JICA team observed that dissolved oxygen was not being analyzed. Oxygen, if present in the feedwater system, will accelerate corrosion of the piping.

According to G-1 on January 1982 annual overhauling report, it was observed that the deposit accumulated

at drum was about 140 kgs., and constituent ratio of the deposits were as follows:

Fe_2O_3 ---------------------- 21.54%
CuO ------------------------ 76.57%
SiO_2 ---------------------- 0.16%

TABLE 2-5 FEEDWATER QUALITY LIMIT DURING START-UP (G-2, S-1, S-2 and M-1)

Process	N_2H_4 ppb	Fe ppb	Cu ppb	SiO_2 ppb	us/cm (After cation)
Fire Boiler:					
Raise Temp. up to 370°F, (177°C)	10 - 70	200	--	--	1
Raise Temp. 400°F (204°C)	10 - 70	100			
500°F (260°C)		100			
680°F (360°C)		100		80	
Turbine Rolling		100	10	40	
On Load		60	5	30	

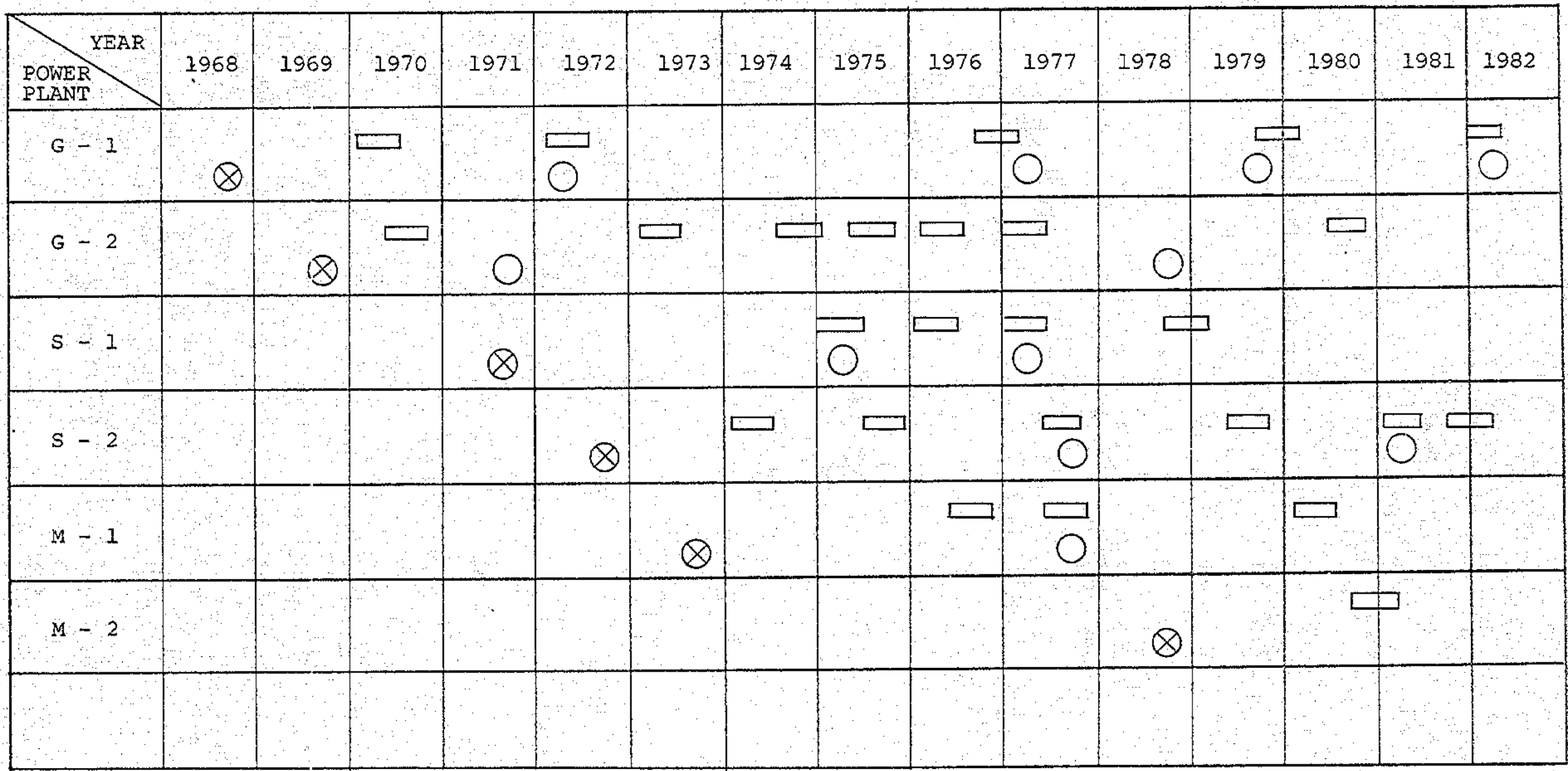
9) Boiler acid cleaning

The post operational chemical cleaning is decided by taking a sample of water wall tube and determining the weight of scale deposits per surface area during annual overhauling. The limits of scale deposits before acid cleaning are 30 mg/cm^2 for drum type boiler and 25 mg/cm^2 for once-through boiler. Based on the above, there were plenty of acid cleaning at Gardner/Snyder Thermal Power Plant boilers.

On the overhauling reports of G-1 and S-2, the scale deposits after chemical cleaning is 10 mg/cm^2 indicating the cleanliness of the boiler tubes.

The recommendation for the acid cleaning of the boiler by the boiler manufacturer is of 10 years before. They recommended that acid cleaning should be done if the volume of deposits taken from the water wall tubes sample is 30 - 45 mg/cm^2.

FIGURE 2-19 BOILER ACID CLEANING



▭ : Annual overhauling

⊗ : Boiler acid cleaning before operation

○ : Boiler acid cleaning, post operation

Recommendation and Advice

There are two (2) factors that will cause interruption of power generation due to improper chemical management.

- Slow deterioration of thermal power plant resulting from improper daily water quality management
- Rapid deterioration of thermal power plant resulting from improper chemical treatment at emergency situation such as condenser leakage and unit start-up.

As a result of the survey, JICA team recommends the following items for proper chemical management:

1) Chemical Staff

a) There exists no problem in organization for chemical staff. The compliment stated in the approved Table of Organization should be filled up promptly. As of now, Gardner/Snyder Thermal Power Plant, Malaya Thermal Power Plant and Tegen Thermal Power Plant need additional personnel of about 23% based on the above.

b) 58% of the present compliment of chemical staff have an experience of less than two (2) years. There is a need to conduct a continuous education program for chemical personnel for new technology. Likewise, chemical key personnel should be sent abroad to get latest information on water and fuel oil treatment.

c) Water management is expected to be increasingly more important as large capacity of nuclear and geothermal power plants are introduced into the Philippines. So that, position of the chemical staff should be graded up corresponding to that of operator.

2) Daily water quality management

a) Measurement of conductivity and dissolved oxygen should be done. Volume of corrosion products carried to the boiler is proportional to dissolved oxygen. This is shown on 1982 G-1 Overhauling

Report where the accumulated deposits on the drum contained high copper concentration possibly coming from the pre-boiler system. When density of dissolved oxygen increased, countermeasures should be promptly taken.

b) Volume of chemicals consumed by every unit should be computed daily, and the chemical consumption should be compared with the other units.

c) Chemical injection system should be made of stainless steel materials. Chemical tanks should be epoxy coated, rubber lined or made of polyethylene materials.

3) Water treatment plant

a) Operation of demineralizing plant, condensate polishing equipment and secondary water treatment should have annunciator alarms to notice abnormal condition of the plant to the control room.

b) Naming and color coding of piping, particularly chemical lines, indication of flow direction should be made for safety purposes.

(1) Make-up water

- Reverse osmosis equipment should be installed as a pre-treatment of raw water at Malaya Thermal Power Plant.
- Demineralizing plant should be overhauled annually and the volume and capacity of resins should be rechecked.
- Equipment listed below should be installed:

(a) Sight glasses for cation, anion and mixed bed exchangers. In the case of cation and anion exchangers, sight glasses should be installed at the operating and backwashing level of resin. For mixed bed exchangers, sight glasses should be installed at the operation, separation and backwashing

level of resin.

(b) Silica meter with recorder and alarm contacts at the anion and mixed bed outlet

(c) Conductivity meter at the inlet of multi-media filter and cation exchangers

(2) Secondary water treatment

Ammonium Hydroxide and Hydrazine system should be injected automatically in proportional to conductivity and feedwater flow.

(3) Condensate polisher

- The regeneration system for G-2 and S-1 ammonex is common. JICA team recommends that each unit should have a separate regeneration facilities. The piping for resin transfer is long, which will cause deterioration of resin by attrition during the process of resin transferring.
- Condensate polisher should be operated by HOH type during condenser leakage and unit start-up. NH_4 type is basically suitable for stabilized power plant. JICA team observed that Gardner/Snyder Thermal Power Plant and Malaya Thermal Power Plant frequently experienced in condenser leakage and unit start-up.

(4) Sampling rack system

In the operation of a power plant, proper water quality management is very important for its continuous operation. Without the necessary feedwater quality monitoring instruments, the power plant cannot be operated at suitable condition.

In view of this, JICA team strongly recommends

to execute the complete rehabilitation of Gardner/Snyder Thermal Power Plant sampling rack system and installation of the different feedwater quality monitoring instruments. JICA team was informed that the Task Force has already prepared the plan for the modification of sampling rack system with corresponding specification. In this regard, JICA team recommends that immediate implementation should be executed.

The main problem on the sampling rack exists in the steam pressure reduction system. If the pressure reducing valve does not work, it will cause damage to the monitoring instruments. In Japan, we use the pressure reducing wire before the instrumentation which works satisfactorily. It is provided in accordance with JIS B-8223.

(5) Water quality monitoring instruments

In high pressure and temperature boiler, like once-through units, ultra pure water is needed for its continuous operation. Therefore, continuous observation of water quality is of the most importance. To accomplish this, feedwater quality monitoring instruments should be installed at the different sampling points of the feedwater system.

The daily analysis in chemical laboratory will check the performance of the monitoring instruments.

JICA team recommends the following instruments to be included in the sampling rack system.

- Drum type boiler

  (a) pH meter at economizer inlet of high pressure feed water

  (b) Silica meter at boiler saline

  (c) Oxygen analyzer at condensate pump

outlet

(d) Hydrazine meter at economizer inlet

- Once-through type boiler

(a) Dissolved oxygen analyzer at the condensate pump outlet

(b) pH meter at the deaerator inlet

(c) Hydrazine meter at the deaerator inlet and economizer inlet

(d) Turbidity meter at the condensate pump outlet

(6) Disposition of abnormality in feed water treatment

The most important factor in water quality management during emergency is rapid acknowledge of the result of analysis. It minimizes carry-over to turbine through boiler. During emergency situation, continuous monitoring instruments are needed to know immediately abnormality, and the measures against it should be taken.

(a) Condenser leak

In order to determine immediately the presence of condenser leakage, a conductivity meter should be installed at the condensate pump discharge. It should be installed after the sample pass through cation resin. During indication of leak, the load of the unit should be lowered so as to enable one-sided operation. Inspect the condenser to determine the location of the leak and possibly to plug the leaked tubes. In this manner shutdown of the unit will be avoided.

During condenser leakage, the condensate polisher should be operated by HOH type.

(b) Unit start-up

The life of the boiler depends on the preservation and proper water treatment during unit shutdown and start-up. If the boiler is not properly preserved, corrosion products in start-up will be carried over to the boiler.

During start-up of the unit, the condenser polisher should be operated by the HOH type. Dissolved oxygen should be measured during start-up and normal operation of the unit. Dissolved oxygen contents should be reduced to the minimum.

(7) Boiler acid cleaning

Acid cleaning of boiler needs a good judgment. During annual overhauling, tube samples should be taken to determine the condition of the boiler. Prior to the acid cleaning of the boiler, the allowable limit of scale deposits should be calculated with boiler heat duty, materials of boiler tube and temperature limit of metal. The allowable limits of scale deposits for G-1 to S-2 boiler is 30 to 45 mg/cm^2 which is a little low. The limit of scale deposits on each boiler tube should be re-checked.

2-1.2.4. MAINTENANCE AND OPERATION

There are some differences in each power plant, however, the actual situations are as follows in general:

A. Maintenance

a. Unit shutdown program for maintenance

1. Emergency shutdown - when shutdown is done immediately due to major trouble or major deviation from normal operation or in case that continuous operation may cause damage of equipment.
2. Scheduled shutdown - when shutdown is arranged for a certain period of time, mostly during weekend or when there is sufficient system power reserved.
3. Preventive maintenance shutdown - scheduled to appraise equipment and components condition so that there is sufficient lead time for ordering. This also gives the opportunity to do preventive maintenance work such as repair of gas leaks, cleaning of lubrication system and repair/-replacement of weakening and/or defective parts of equipment or components.
4. Annual overhauling - normally done in 30 days but can be extended if there is/are major repair works.
5. Turbine and boiler overhaul - normally done every four (4) years for 45 days, however, schedule can be extended if there is/are major repair works.

NOTE:

1. Due to lack of sufficient reserve, frequent outage of other units and/or extended over-hauling time, overhauling schedule of other units are allowed to slide or to be deferred for a period of time to augment the system power requirements.

2. NAPOCOR's concept is to avoid shutdown as much as possible and to prepare for shutdown when the shutdown is necessary. This concept, however, suffered some set-back because the Central Maintenance Division (CMD) could not provide the necessary support in most cases. They could not immediately respond if the duration of shutdown is short or if the personnel are assigned to other works.

   CMD can handle all maintenance and overhauling jobs if necessary parts are available on time, but cannot handle all the work when emergency repairs will also be done at the same time. CMD is in the process of hiring skilled personnel from AG & P, EEI and other sources.

The present approved number of complement of Maintenance Sections of Power Plants are of very small capacity.

B. Determination of maintenance period

   a. Overhaul of big capacity unit will be carried out mostly during rainy season.
   b. Overhaul of power plant is required to be delayed from the original schedule because the trips of other units occur frequently and because of lackness in power supply, and the overhaul is forced to be carried out when the plant tripped.
   c. Availability of spare parts

C. Determination of items for maintenance works/ repair works

   a. Logbook for deferred jobs is maintained.
   b. Any revision/improvement planned for implementation during shutdown.
   c. Result of inspection during unit shutdown may require additional repair works.
   d. Check list for overhauling of unit
   e. Recommendations by manufacturers

D. Judgment of results of maintenance works

Results of maintenance works are evaluated by,

a. The Plant Services Section Results Unit,

b. Quality Assurance Group,

c. Plant Management, and

d. Operation Section

E. Administration of maintenance data (records)

a. Maintenance supervisors of Electrical and Mechanical Sections

b. Central Maintenance Supervisor

c. Quality Assurance Group

2. Performance Control

A. Efficiency control of a unit - by Results Group

a. Boiler leak

b. Close cycle system leak

c. Boiler efficiency

d. Boiler performance

e. Specific heat consumption rate

f. Turbine stage efficiency

g. Air heater performance

h. Condenser performance

i. HSCC performance

j. FW heater performance

k. Sootblower pressure check

l. Power plant performance

m. Outage statistics

n. Vibration check of equipments

B. Fuel consumption program - MMRC

C. Fuel purchase program - MMRC

D. Administration of chemical and fuel consumption - Chemical Section

3. Operation

A. Keeping of operation records - Results Group

B. Analysis of operation data:

a) Supervisors (Operation and Results Section)

b) Quality Assurance Group

C. Planning and execution of tests
   a) Supervisors (Operation and Results Instrument)
   b) Technical Service Division

D. Analysis of test results
   a) Supervisors - Instrument and Results

E. Purchase program of Spare Parts
   a) Section Heads of Mechanical Maintenance, Electrical Maintenance, Instruments and Results and Chemical Section

RECOMMENDATION AND ADVICE

Even if there exists afore-mentioned disadvantage for keeping the plants in proper condition, it will be recommended to follow-up the following recommendations/-advices at least as a part of the rehabilitation work:

1. For maintenance

   Attached check sheet (APPENDIX II) will act as one of applicable check sheets for the existing power plants to be followed-up in addition to each manufacturer's recommendations. On the base of actual plant survey, the following items are especially insufficient in the actual situation of periodical inspection, and these items shall be added to existing NAPOCOR's standard maintenance concept.

   a) Load test of each auxiliary equipment
   b) Interlock test of each auxiliary interlock test
   c) Flushing, if necessary
   d) Water quality analysis
   e) Adjustment of turbine control valves (governing valves)
   f) Leakage check for tubes of heat exchangers by eddy current test
   g) Electrical equipments
   h) To use skyfoot for better safety in case of execution of actual work in the boiler furnace

2. Spare parts management and administration

It looks that the spare parts management and administration are made by each power plant, and there are differences respectively in

1) Administration of number/kinds of spare parts
2) Standard spare parts storage and administration system

However, since the "SPARE PARTS REQUIREMENT OF MMRC PLANTS FOR OVERHAULING AND REHABILITATION" will be used as basic spare parts list for each plant, improvement for spare parts administration/storage/control will be rearranged on the base of the above list.

After the re-arrangement, following items will be followed-up continuously in each plant:

1) Spare parts must be ordered to original manufacturer (supplier) to keep the unit reliability and guarantee figure except in case of originally defective equipment or materials.
2) Every parts and materials consumed in an overhauling will be supplemented in short term.

3. Operation

It would be understood that the operators are trying their maximum effort even if there are so may defective monitoring, instrumentation and control systems.

However, it appears that there are some troubles based on misoperation or lack of fundamentals and required action.

The cause of these insufficient operation will be due sometimes to attitude, discipline and lack of knowledge in their plant systems.

Accordingly, frequent brush up of operators in knowledge and in discipline will be necessary, and the following ways will assist the brush up in addition to standard education or OJT:

1) Case study - Brain storming

2) Design review of all existing systems - Group discussion

3) Operating condition analysis, short time discussion in shift duty

2-2. REHABILITATION ITEM AND WAY-GENERAL (SHORT TIME ITEMS)

At this stage, NAPOCOR has already fixed the rehabilitation items in detail under close contact with the equipments original suppliers (manufacturers) and the details are listed up in "Spare parts equipment of MMRC (Metro Manila Regional Center) Plants for Overhauling and Rehabilitation" which includes total and breakdown cost (including foreign local labour), delivery term and rehabilitation schedule for each plant.

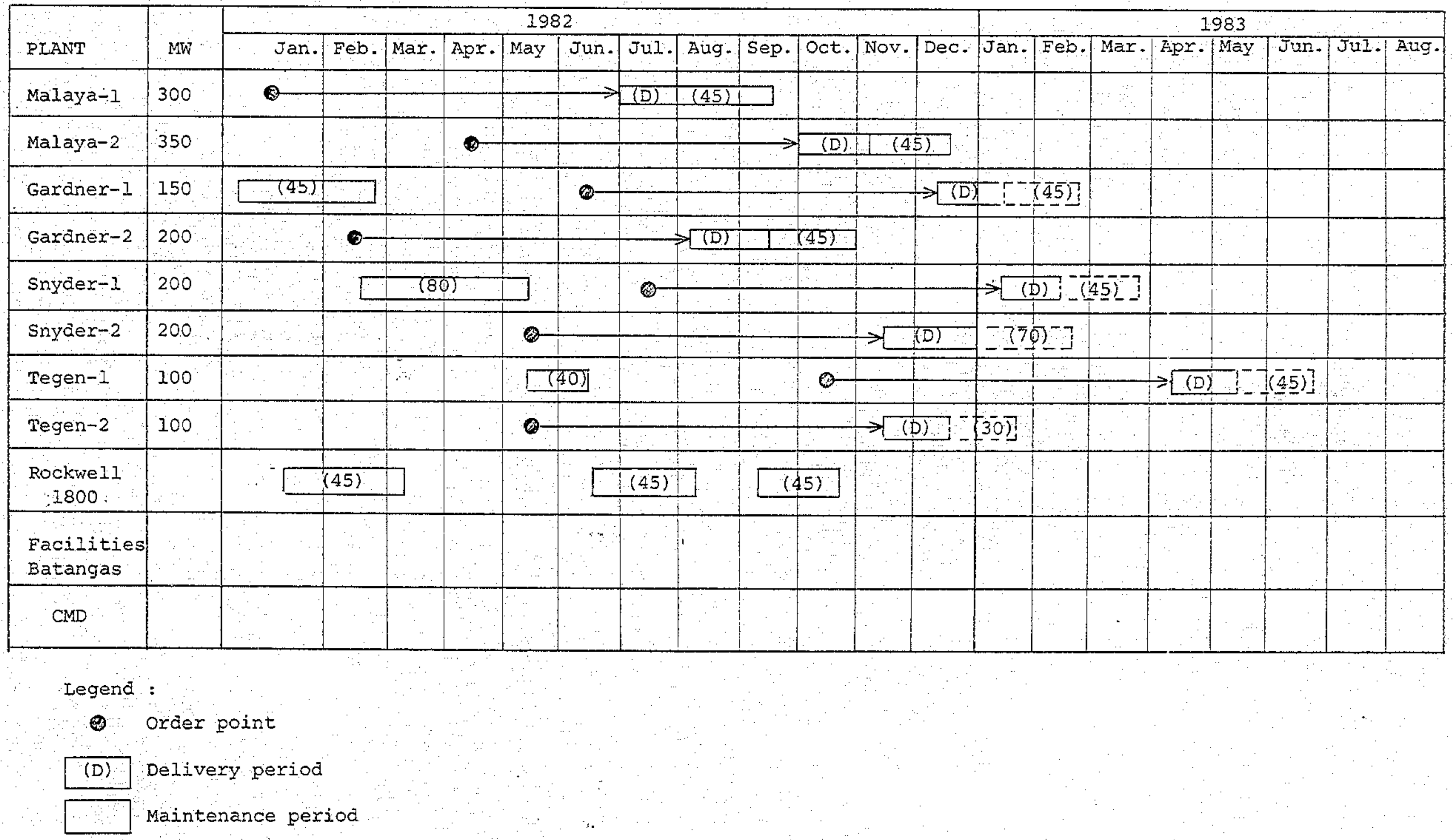
The rehabilitation schedule is shown in Figure 2-20 and the cost/delivery term have been confirmed with each original suppliers (manufacturers), and the parts and materials for rehabilitation have been ordered, or are under ordering in conformity with the schedule.

The National Power Board has always given support to the rehabilitation work of NAPOCOR. Additional financing has already been acquired.

The basic concept on the determination of those detailed parts and materials is to have approximately 10% spare after the completion of rehabilitation, but the rate of spare will be different on each item.

However, the "Spare Parts Requirement of MMRC Plants for Overhauling and Rehabilitation" which covers all the fields of plants on the base of trouble experienced up to now will be basic and very useful spare parts list of each power plant, and it will give effective assistance in further maintenance of power plants after each rehabilitation since the list covers B.T.G. auxiliaries, monitoring, instrumentation and control system in detail and afore-mentioned recommendation by Quality

FIGURE 2-20 SPARE PART DELIERY PROGRAM FOR MMRC SYNCHRONIZED WITH THE MAINTENANCE SCHEDULE



Assurance Group.

Accordingly, the most important matter at this stage is, "how to maintain the plant, how to fix the skill and discipline of personnel throughout" and "to keep the plants in appropriate conditions."

2-2.1. GENERAL PHILOSOPHY

Service life of major components and equipment is being determined so that these can be serviced or replaced before they break down.

The NAPOCOR's basic idea/philosophy on the rehabilitation are as follows in principle and JICA team also agrees with this basic concept in principle, however, for the other items which are not included in that "Spare parts Requirement of MMRC Plants for Overhauling and Rehabilitation", that is, the items to be applied to future plants, the above-mentioned section 2.3.2 Fundamental Matters Common to Power Plants will be referred to.

2-2.2. BOILER

Replace all the defective parts including monitoring sensor, thermocouples monitoring tube metals and fluid temperature, local temperature indicators, arc welding rod tubes, etc.

2-2.3. AIR HEATER

Replace all the defective parts including heating element, air motor, coupling bolt, bolt-nut, washer, etc.

2-2.4. BOILER AUXILIARIES

Replace all the defective parts including feedwater control valves, BFP minimum flow valves, dust handling system, etc.

2-2.5. TURBINE-GENERATOR

Replace all the defective parts including bearing, buckets, LSB unhardening (leading edge), and install additional oil purifier, steam seal regulating valve, etc.

2-2.6. TURBINE-GENERATOR AUXILIARIES

Replace all the defective parts including feedwater heater tubes, condenser tubes, condenser rotary vacuum pump, etc.

2-2.7. WATER TREATMENT SYSTEM

Replace all the defective detectors and resin regeneration tower, install additional water treatment system through raw water treatment and water demineralizing equipment, and replace piping material (carbon steel) up to make up water (condensate storage) tank with stainless steel, and provide additional laboratory instruments in Malaya Thermal Power Plant.

2-2.8. MONITORING, INSTRUMENTATION AND CONTROL SYSTEM

At this stage the scheme of existing system will be left as it is now (complete system replacement e.g. electronic-pneumatic-digital is not included, however, study is on-going for the replacement of the existing system with electro-pneumatic digital system), however, better maintenance will be considered after replacement of defective parts including EHC, power pack unit, H/A selection station, combustion control system, instrument air compressor/station service air compressor, compressed air dehumidifier, auto turbine tester, detectors, transmitters, integrators, transducers, etc.

2-2.9. HUMAN DISCIPLINE AND TRAINING

It is understood that this is the most important subject to maintain the plant in proper condition after the physical rehabilitation of the plants. If the improvement of this field and mental/additudal rehabilitation are not achieved, the physical rehabilitation will lose its effect within short term, and the physical rehabilitation will be meaningless.
Accordingly, NAPOCOR wishes to proceed to resolve this subject thoroughly and has intensive request to JICA team to assist NAPOCOR in the human education including discipline.
This education will also be reflected to the operation/ maintenance of the other plants and future plants.

RECOMMENDATION AND ADVICE

The rehabilitation program is intensively prompted by the NAPOCOR Task Force together with the plant staff effectively. JICA team would like to advise some idea on the actual replacement/repair work to maintain the effect of the rehabilitation.

1. Acknowledgement of all the replacement and repair items by all plant personnel
    1) Items
    2) Reason
    3) Retraining on replaced parts, materials and systems
2. Repairing and cleaning up of while plant especially electrical instrumentation and control parts, system, cabling/wiring/terminal including panel in the same condition as similar initial commissioning.
3. Complete repairing, maintenance work of miscellaneous matters such as building, heating insulation, piping leakage, miscellaneous drainage collection piping, etc.
4. Fluid identification and flow direction marking on the piping
5. Mounting nameplates on valves
6. All control system loop check/correction
7. All alarm and interlock test/correction
8. Calibration of all major end detectors/sensors
9. Retraining of operation and maintenance personnel
10. Establishment of spare parts administration system in the plant

Items listed above will be indispensable for recovering the plant functions and further maintaining the plant, and will be practiced during the plant shutdown for the rehabilitation work, in other words, the rehabilitation effects will be missed in short term if these are not practiced in the rehabilitation work at the same time.

These combined programs will allow the plant personnel to recognize their plants and improvement of discipline. The actual rehabilitation will not be achieved by outer force only, but the internal recognition is the most essential requirement.

Through these accompanying rehabilitation items, some improvement ideas will be created by the plant personnel, and following permanent, continuous system may also assist the improvement of performance in human and plant.

1. Application of improvement proposal by each personnel
   In this case, the most essential matter is the number of proposal not contents and/or outward appearance.
   After that, evaluation/brain storming/case study will be applied to the proposal to brush up everybody, and bonus should be given to the personnel proposed the applicable ones.
2. Setting of annual zero defect campaign term
   During the term, special attention shall be paid on their plant management, plant system, operation, maintenance, machinery/facility/equipment/device and ordinal routine work, and freshen up discipline and attitude.

<u>NOTES AND REMARKS</u>

1. Superheater tube material replacement with SUS-321
   For secondary superheater, the tube material (STBA-24) exposed to high temperature flue gas path are going to be replaced with SUSS-321. (Once-through boilers M1, G2, S1 and S2). The STBA-24 is appropriate material in case that the combustion control is working properly and the water/-steam purity is controlled adequately.
   The metal temperature is fluctuating during actual operation, and the temperature exceeds sometimes the allowable temperature limit of the STBA-24. Generally, tube materials up to 538°C class is Cr-Mo steel, 566°F class, SUS. Resulting from the actual operating conditions, the materials

having allowable temperature limit will be suitable for the portion.

However, sufficient countermeasure to prevent stainless steel from oxide scale must be taken into account.

Properties

Troubles due to the SUS oxide scale occurs mainly since the SUS oxide scale in stainless steel is formed inside the tube during operation, and at the start-up and shutdown the scale is stripped off due to thermal expansion difference between the tube material and scale, and there is possibility of clogging the steam path.

There is tendency of scaling of alloy steel in Cr-Mo steel e.g., STBA-22, 24 especially in steam temperature more than approximately 600°C, however, the thermal expansion difference is little between the tube material and the scale, and there is less possibility of stripping off of the scale in alloy tube.

Contents

Outer layer: Mainly porous Fe_3O_4

Inner layer: Fe, Ni, Cr oxide

The scale forming rate increases in accordance with temperature.

Cautions

- To keep dissolved oxygen contents in feedwater and steam as low as possible
- The scale forming grows up into troublesome range in operating hours of approximately 20,000 - 30,000 hours generally and detail inspection should be practiced especially after those operating hours, and that steam-blowing out is necessary after three (3) years.

2. Monitoring, instrumentation and control system

In addition to the replacement of parts, at least following items must be practiced completely at the same time of the replacement:

1) Check of signal transmission between each control system
2) Control, monitoring and annunciator system loop check
3) Calibration of all sensors and detectors

4) Clean up of instruments, wiring and terminals - central control room and local (especially local control panel inside)
5) Mounting of proper support for instruments especially around main turbine
6) Addition of flexible tube for instrumentation wiring especially around main turbine

2-3. SURVEY RESULTS OF ELECTRIC SITUATION SURROUNDING METRO MANILA

2-3.1. OUTLINE OF LUZON POWER NETWORK

Electric network of Luzon island is composed of three (3) elements: the first is hydraulic power from North Luzon -- Pantabangan 100 MW, Angat 218 MW and other small hydraulic power station group, and the Bataan Thermal Plant of 225 MW; the second, in Metro Manila where its thermal plants, like the Sucat 850 MW and Malaya 650 MW are located; and the third, geothermal plants, Tiwi 330 MW, Mak-Ban 220 MW and reversible hydraulic power station of Kalayaan 300 MW which are located in Southern Luzon. Most of these stations are connected with 230 kV transmission line (T/L). At San Jose, Balintawak substation (S/S), electric power for Metro Manila are supplied by means of 230 kV/115 kV step-down transformer and Sucat Thermal Power Plant (T/P) and Dolores S/S, electric power for Metro Manila are directly from 115 kV system as shown in Figure 2-21. In the Metro Manila, network is connected with 230 kV and 115 kV T/Ls for loop system and substations bus is applied 1-1/2 CB scheme, so system reliability is rather high grade, and in case an accident occurs in any substation, transmission line, power supply will be continuing or will recover in short time. Especially, improvement of 230 kV system has been developed by NAPOCOR effort in the last several years. The following items recommended by the report of MOE committee EPSL (March 7, 1981) are already finished.

(1) 4 x 15 MVAR reactors -- already under operation at Gumaca, Labo, Naga and Daraga
(2) Commissioning of Kalayaan hydraulic power plant and improvement of T/Ls concerning Kalayaan hydraulic power plant

And the following items are now under construction or planning:

(1) Planning of Sucat S/S stepping up (construction of new T/L and 300 MVA x 2 transformers)

(2) Stepping-up of Dolores S/S 300 mVA x 2 transformers under construction

(3) Additional 300 MVA x 1 transformer at Balintawak S/S under planning

(4) Additional 300 MVA x 1 transformer at San Jose S/S under planning

It is easily understood that completion of abovementioned items makes the system more reliable, because 230 kV T/L lines surround 115 kV networks of the Metro Manila.

Then the reliability of the Metro Manila network is growing up year by year. By the way, comparing between the load peak demand of Luzon grid and total dependable capacity, the reserve capacity is too small as shown on Figure 2-21. And the most important matter for system reliability improvement are development and/or exploration of new power sources.

But on the point of view of the utility operation, following items are recommendable in order to improve system reliability.

(1) Coordination between NAPOCOR and MECO, and identification of responsibilities between NAPOCOR and MECO, respectively

(2) Training for technology development of the NAPOCOR employees standing on the point of long term view

2-3-2. REASONS AND COUNTERMEASURES FOR TRIPPING OF GENERATOR CAUSED BY FAULT/DISTURBANCE OF LUZON POWER SYSTEM AND/OR ELECTRICAL EQUIPMENT

A. Summarized Data:

Table 2-6 shows the data on tripping of generator caused by fault/disturbance of Luzon power system and/or electrical equipment for Sucat and Malaya T/P recorded from 1971 January to 1982 April. total number of accidents is counted at 44.

In the process of checking the data, following facts were identified:

(1) Some reports are lost (e.g., 31 and 39)

(2) Some drawings are not up-to-date one.

(3) The reasons of faults are not so clear on some reports (e.g., 19 and 20).

(4) Sometimes inspection, maintenance and trouble reports are not prepared by maintenance or operation section.

(5) Reports are not computerized.

(6) Some reports show that the time relays settings are not coordinated with each other (e.g., 8 and 11).

(7) Many lightning arrester faults have occurred (e.g., 13, 26, and 44).

(8) Overheat occurrences of lead wire junctions and/or terminal parts of main transformer are estimated caused by corrosion of bolts of bolted type clamp and bolted type terminal (e.g., 4, 10 and 14).

(9) The report of mis-operation was understandable because at that time the operator was obliged to operate for long term caused by no next shift coming, then he misjudged his operation due to fatigue. The lack of shift replacement was the result of many skilled engineers leaving their job to work abroad, and consequently average technical level of NAPOCOR engineers is going down.

B. Countermeasures Against Above-mentioned Problems:

Countermeasures against above-mentioned problems are as follows:

(1) Such kinds of reports should be kept strictly on file and properly arranged.

(2) Drawings and instruction manuals, documents of equipment ratings, etc. should be arranged on the condition of up-to-date all the time.

(3) The cause of failure should be classified, identified and it should be fed back to maintenance for repair/ checking on the equipment itself and on all similar types of equipment.

And the superintendents (in case of T/P operation, maintenance and technical service section superintendents) are responsible for the above-mentioned three (3) items 1, 2 and 3.

(4) The reports should be prepared in every case of T/P, S/S troubles. Inspection work should be done by operation section, and maintenance works should be done by maintenance and technical service sections. Necessary inspection check list shall be made by each T/P and S/S and maintenance check list shall be made by maintenance and technical service sections or technical services division of the regional office.

(5) All accidents and failure shall be recorded into a certain report format which can be used for computerization. Computerized system gives statistical management and administration, and appropriate, similar countermeasures applicable for all type of equipments.

(6) The relaying equipment for station service shall be coordinated with T/L protection relaying equipment. There are some relaying equipment which shall be tested immediately.

(7) Following investigation for lightning arresters should be done immediately.

* Rating Voltage - The arresters can withstand against system overvoltage in case of sudden load shedding, or not.
* Contamination Characteristics - The existing arresters have appropriate anti-contamination properties, or not, i.e.
  Bataan -- Design of heavy zone should be applied.
  Others -- shall be "medium zone".

(8) Overhauling of junction and terminal points of lead wires shall be done at same time of generator overhauling and compression type clamps/terminals, and stainless bolts are better than existing bolted type clamps and terminals.

(9) Training of employees will be mentioned in other chapter so in this clause, several items shall be suggested on the different point of view.

* Interchanging some employees among the operation and maintenance or technical services section.
* For efficient utilization of NAPOCOR employees, it will be better to absorb the peak works by certain firm, which is preferable subsidiary company of NAPOCOR.
* Number of operators in T/Ps and S/Ss shall be rechecked (e.g., number of MECO operator of Balintawak S/S is one shift).
* Completion of "Standard Operating Procedures (Emergency System)" is highly evaluated, and such kind of effort is very respectable. NAPOCOR should make every effort continuously to make the "Standard Operating Procedure (Normal Operation)".

2-3.3. RESULTS OF SITES SURVEY AND COUNTERMEASURES FOR FAULT DECREASING

Sucat, Malaya, Tegen, Bataan T/Ps and Load Dispatching Center (LDC) (existing and new), Dolores and Balintawak S/Ss were surveyed and discussions were held at every station/plant. And our conclusions for the countermeasures are as follows in connection with the surveys and discussions.

A. Improvement of Facilities:

(1) Application of automatic oscillograph

In order to analyze the system disturbance and relay activations, JICA team recommends that automatic oscillograph should be installed at important stations/plants. Table 2-7 shows one of JICA team's

ideas.

Inkless type oscillograph is recommendable because of its simple operation.

Sucat T/P has an optical type automatic oscillograph made by Hathaway but now in out-of-order condition because of lack of oscillograph paper.

(2) Application of high speed reclosing system

In order to improve system reliability on the 230 kV system, single phase reclosing scheme will be recommended and which will cover approximately 80% of line faults. Table 2-8 shows one of JICA team's ideas.

(3) Improvement of telecommunication system

Considerably wide extent of improvement of telecommunication system is included in the LDC project which is now proceeding. JICA team expects that this project shall be done completely by the target date (1983), and if completed earlier, the better.

And JICA team guesses, even after completion of the project, the NAPOCOR communication system may not be satisfactory enough, and next advantage plan using micro wave should be also considered continuously.

(4) Application of solid state type relaying equipment

In the future, NAPOCOR should consider the application of solid state type relaying equipment which has high equipment reliability, shortening of the relay activation time and easy maintenance (automatic inspection/continuous monitoring system can be available).

(5) Each relaying protection zone shall be overlapped.

There are some blind points in NAPOCOR system, however, there is no blind point in MECO system, and NAPOCOR should revise the protection scheme by turns in future.

(6) Insulation design for distribution line of 34.5 kV and below shall be preferable to apply the IEC

recommendation.* And existing circuit shall be replaced with the insulators which have longer leakage distance in the same time of repairing/remodelling/reconstructing (detailed rehabilitation) term. Replacement of insulators with higher voltage rating is in progress in MECO.

(7) Maintenance equipment, instruments and tools possessed in the Regional Offices were checked, and provision of additional one set of relay testing equipment and others shall be recommendable for each Regional Office. And some additional new vehicles for transportation of testing equipment and crew are also recommendable.

B. Organization and Training:

(1) Dispatch Center

According to NAPOCOR's plan, new LDC will put in service soon and training for employees who will engage in the new LDC was done by NAPOCOR i.e. many employees have been dispatched to U.S.A. for the training. In spite of immense expenditure, the decision which was done by NAPOCOR Board is very respectable.

So, the outstanding matter of LDC concerned is to establish "operation procedures" in which MECO, T/Ps, S/Ss and many cooperatives (already mentioned in paragraph 2-3.1) will be involved.

(2) Identification of responsibility

JICA team guesses some problems might occur caused by the following facts:

* Classification for operation and proprietary rights are sometimes confused between NAPOCOR and MECO.
* Some equipment are commonly used for NAPOCOR and MECO (e.g., a kind of C.T.s).

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*Guide for the choice of insulation under polluted condition (1980)