5.3.4 Plant System

As a result of survey of power plant facilities, some recommendations on design of future construction of power plant are summarized here.

1) Turbine Bled Steam Line

The turbine bled steam non-return valves closed by spring cannot isolate the line tightly by spring force to avoid water induction and that manual operation valve handwheel is not suited for easy operation because of small size.

These valves should be operated by motor, hydraulic or pneumatic actuator for quick operation. At least one additional motor driven non-return valve having interlock with higher heater drain level should be installed to prevent strictly water induction in each bled line. This should be also applied to deaerator heating steam line.

The No. 2 bled steam line has been cut out in Gardner/ Snyder Power Station by the reason of unsuited steam conditions for steam coil air preheater. This was definitely resulted from defective design. Interface point between boiler side and turbine side should be definitely confirmed at plant design stage.

2) Non-Return Valve Before Economizer Inlet

To prevent back flow into HP feed water heater, it is recommended that the non-return valve should be installed between economizer inlet and final HP feed water heater. The units to be applied are as follows:

G-2 unit

S-1 unit

S-2 unit

M-1 unit

Note: Non-return valves for G-1 and M-2 units were installed.

3) <u>Feed Water Heater By-pass</u>

HP feed water heater by-pass line and valve have not been provided even if many tube leakage troubles occurred.

In case of heater tube leakage, to prevent water induction, it is recommended that heater by-pass line.

The units to be applied are as follows:

S-1 unit

M-1 unit

M-2 unit

At present, the by-pass lines for G-2 and S-2 units were installed as follows:

But taking the operation at the emergency into consideration, the following by-pass system is preferable.

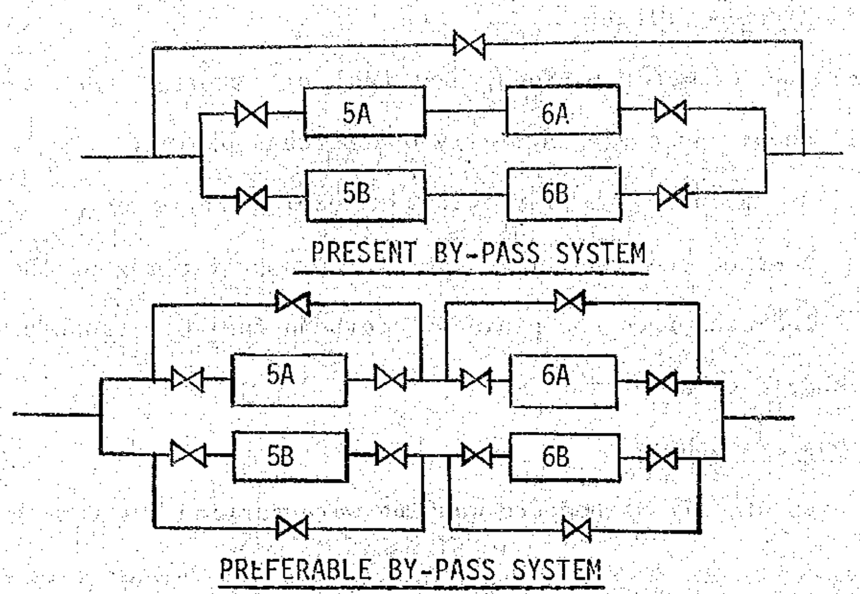


Fig. 5M-37 HEATER BY-PASS SYSTEM

4) BFP Minimum Flow System

BFP minimum flow pipings should be provided separately up to deaerator.

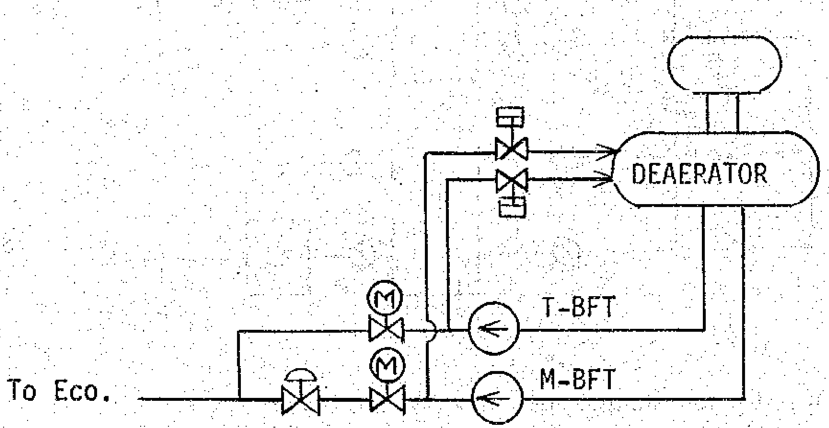


Fig. 5M-38 BFP MINIMUM FLOW SYSTEM

5) Fuel Oil Transfer Piping

Fuel oil transfer pipings from fuel oil storage tank to fuel oil supply pump are partially underground piping.

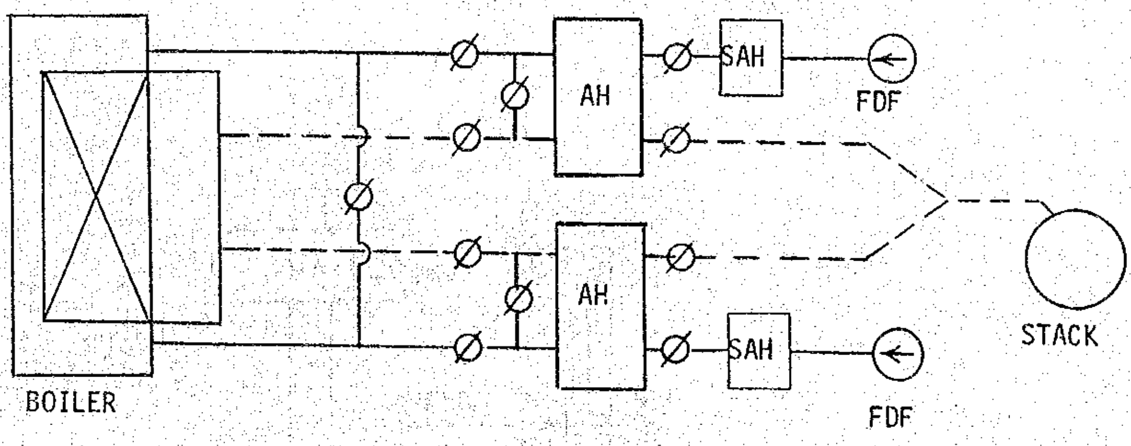
For the purpose of prevention of piping corrosion, for easy maintenance and supervision and for prompt finding of the fuel oil leakages from the pipings, overhead fuel oil transfer piping should be adopted.

6) Air Preheater Washing

At present, air preheaters washing were carried out during unit shutdown in every plant. Furthermore, air heater cloggings have occurred frequently in each plant, and power plants had to be shutdown only for air preheater washing.

Air preheater washing can be carried out at low load operation (about a half load of power plant), that is, one sided operation if air and gas ducts are improved as shown below.

Fig. 5M-39 AIR & GAS DUCT SYSTEM



Major improvement items are as follows:

1. Additional installation of air preheater by-pass dampers
2. Additional fixed type washing water jet nozzles in air preheater, water drainage piping beneath the air preheater casing

3. Additional installation of gas and air temperature indicator or recorder

4. Additional installation of water mixing heater

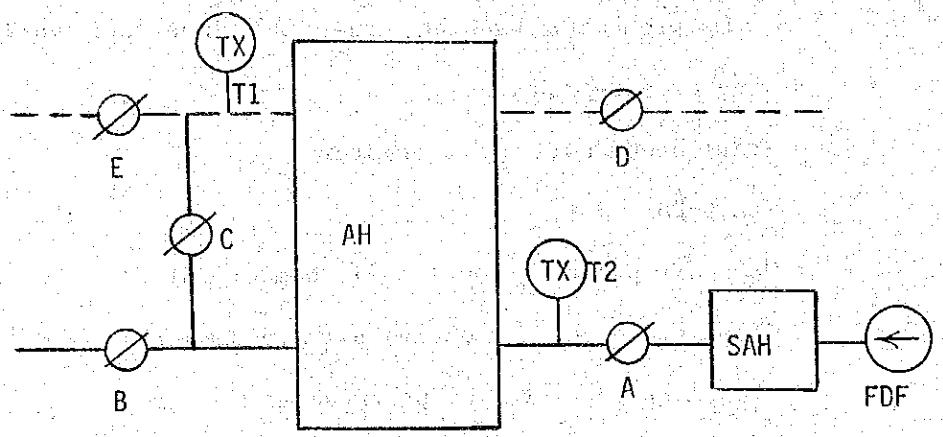


Fig. 5M-40 SUPERVISORY INSTRUMENTS FOR AH COOLING

Outline of air preheater washing procedures are as follows:

Air Preheater Cooling

- Load down to about one-half load
- Open AH outlet air tie damper
- Confirm the burner firing condition
- Close air preheater inlet gas damper
- Close air preheater outlet air damper
- Open air preheater by-pass damper
- Stop steam coil air preheater
- Cool down air preheater element up to the following conditions

  $T_1 - T_2$ 100°C

  T_1 150°C

- Stop air preheater and operate air motor
- Stop FDF fan

Air Preheater Washing

Completeness of the washing should be determined by drainage quality analysis.

Drying of air preheater

In air preheater washing, the most important work is drying of air preheater.

- Start steam coil air preheater
- Start FDF
- Open air preheater outlet air damper (B)
- Close air preheater outlet air tie damper
- Close air preheater by-pass damper

7) Central Control Room

In central control room, there are installed many kinds of instruments such as controllers, supervisory instruments (indicator and recorder), relays, switches, alarm annunciator system, etc. inevitable for safe, stable and continuous operation of power generating units. Such instruments include electronic type and electrical contacts affected by ambient temperature, humidity, gas, dust and soot. Especially, sulfurous acid gas leak from boiler causes corrosion in electrical contacts and electronic devices.

For planning and design of central control room, it is recommended that:

- The gas from the boiler area should not be introduced into central control room, fresh air should be introduced through another air duct.

- Hot air, dust and soot introduced from the openings for cable marshalling should be strictly avoided with the aid of sealing plate and seal compound.
- Number of door in central control room should be limited to two or three at maximum.
- To avoid entry of hot air, dust and soot from the outside, room for cable marshalling should be additionally provided under the central control room.

8) Plant Interlock System

Plant interlock system is the most important system among the plant systems, and should be highly reliable to prevent the plant from trouble. Furthermore, in case there is no trouble, the detectors for plant interlock should not be actuated due to its self-malfunction.

To up-grade reliability of the plant interlock system and to prevent plant trip from malfunction of the detectors, 2 out of 3 system should be applied to the system. In this system even in the event that one detector is defective or actuated due to malfunction, the plant can be continuously operated.

A 2 out of 3 system should be applied to the detectors which directly transmit the trip signal from the locally mounted sensors.

Generally, the 2 out of 3 system is applied to the following sensors:

Boiler

- Economizer inlet feedwater pressure switch
- Feedwater flow switch
- Furnace draft switch

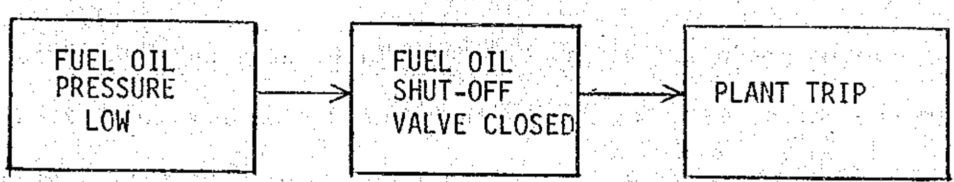
- Main steam pressure switch
- Main steam temperature switch
- Fuel oil flow switch

Turbine

- Condenser vacuum switch
- LP turbine exhaust temperature switch
- HP/LP heater drain level switches
- Turbine bearing oil pressure switch
- Other switches which initiate the plant tripping

In addition to the above it is better to apply 2 out of 3 system to sensors like fuel oil pressure switch which indirectly transmits plant trip signal.

Fig. 5M-41 PROCESS OF PLANT TRIP



9) Instrument Air System

Instrument air supply system is very important especially in case the pneumatic control is applied to ABC system and instrument air supply failure will lead to plant trip in the worst case. In the event of air failure, the air is supplied from station service air system. However, the station service air should be applied to instrument air line only in the worst case because the station service air is dirtier in quality in comparison with instrument air.

10) Main Transformer Line

Connection between main transformer and associated substation is by overhead line like as transmission line. Especially, in Malaya Thermal Plant, the main transformer line is about 1000 m long. This line has probability to be hit by lightning and failure of insulator due to salt and dust contamination.

Main transformer line cannot be reclosed immediately unlike to transmission line. Therefore, the main transformer line should be designed as underground cable to have more reliable power plant system.

11) Station Service Auxiliary Power Units

Gardner/Snyder Thermal Power Station has experienced a flooding of the whole power plant area in 1972, and tide level at that time was reported to be higher than 1,600 mm from the basement floor. Not only metal-clad switchgear, power center units and motor control center units but also almost all of the motors and electrical equipment were completely flooded at that time.

To prevent the above problems, the station service auxiliary power supply system such as metal-clad switchgears, power center units and motor control center units, at least, should be installed in an electrical room with sufficient ventilation on the second floor.

12) <u>Establishment of Design Standards</u>

Power plant system should be planned, designed, erected and installed by a definite owner's philosophy, not only by manufacturer's philosophy.

Therefore, owner of electric power supply system should have design standards. According to these design standards, all the power plant system should be standardized.

The design standards necessary for planning, design, erection and installation of thermal power plant should be established and should include the following standards at least:

- Service building air conditioning design standards
- Electric motor design standard
- Conduit pipe installation standard
- Station battery system design standards
- Control panel design standards
- Cable sizing design standards
- Station service electrical system design standards
- Emergency generator design standards
- Lighting and electric outlet design standards
- Motor-driven valve design standards
- Protection relay setting standards
- CT and PT installation standards
- Elementary control wiring diagram standards
- Local instrumentation standards
- Alarm annunciator system design standards
- Cable tray and trench design standards
- Plant interlock design standards
- Cable specification standards

- Instrument piping standards
- Turbine oil management standards
- Selection standards of control valve
- Allowance capacity and number of auxiliary
- Plant equipment naming standards
- Piping identification mark standards

5.4 REHABILITATION PROGRAM

5.4.1 Rehabilitation Program Under Implementation of NAPOCOR

1) Rehabilitation Program

Considering the situations seriously that brown-out is caused by the deterioration of output of thermal power plants in Metro Manila, NAPOCOR started the Rehabilitation Program of thermal power plants with the budget of P120M in August, 1979.

The objective of this program is to recover the reliability of all MMRC thermal power plants except rockwell, to attain their rated output in 1983. This Program was revised in September, 1981 in view of additional findings during the first stage of overhauling and inspection of the units which increased the estimated cost up to ₱250M. Meanwhile, NAPOCOR established a Task Force consisting of Quality Assurance Group (Q.A.), established in February, 1981, and Planning and Programming Group (P & P), established in November, 1981, directly connected to Management in order to promote the smooth progress of the Rehabilitation Program.

In September, 1981, Study Team of Utility Operations was also established, thus various efforts have been exerted by NAPOCOR.

According to the report in February, 1982, some improvement in output and recovery of reliability were recognized in the power plant.

Increase in the total budget of the rehabilitation up to P298.8M is expected, however, because of the delay in the overhaul schedule, the shift to later years of the rehabilitation works seems to be inevitable.

2) Actual Results of the Program

The actual result after the implementation of the rehabilitation program is as follows:

a. Overhaul Schedule

Figures in blackets show periods of overhaul.

Unit \ Year	1979	1980	1981	1982	1983
Gardner-1	10/24 (81) 1/12			1/13 5/10 3/5 (61)	4/19 (45) 6/2
Gardner-2		8/6 10/22 (77)		6/7	6/4 7/18 (45)
Snyder-1	4/23 10/22 (150)		10/26 1/14 (82)	9/12 12/20 (100)	10/11 11/24 (45)
Snyder-2	6/1 8/21 (82)		2/23 8/19 (175); 11/20 4/9 (151)		7/20 10/8 (80)
Malaya-1		2/22 7/9 (139); 10/29 2/1 (96)			2/1 4/16 (75)
Malaya-2		10/21 2/9 (111)		11/30 1/28 (60)	11/26 1/8 (45)
Tegen-1	4/3 5/7 (35)	9/10 11/10 (30)		10/27-11/27 (32)	12/1 12/30 (30)
Tegen-2		1/21 3/16 (55)	10/30-12/19 (51)		2/7 4/7 (30)
Rockwell	2/20 4/7 (47); 6/30-9/11 (74)	5/21-7/25 (66)	9/24-12/13 (81)	7/6-8/14 (55); 8/29-10/22 (62); 12/22-2/4 (45)	

▭ Overhaul(actual)   ⊏⊐ Plan   ---- Accident

b. Budget

(Unit: M₱)

	1979	1980	1981	1982	1983	Total
Gardner 1	11.25	1.57	1.21	16.79		30.82
Gardner 2	1.65	8.87	8.96	27.84		47.32
Snyder 1	0.78	1.30	10.21	11.01	17.65	23.30
Snyder 2	6.48	1.95	28.02	34.57		71.02
Malaya 1	-	13.22	2.54	17.14		32.90
Malaya 2	-	4.78	3.93	27.77		36.47
Tegen 1	0.25	5.94	0.15	7.30	7.58	13.64
Tegen 2	0.25	3.21	5.80	8.86		18.12
T O T A L S	20.66	40.84	60.82	151.28	25.23	273.60

1982, 1983 : Estimate

c. Generation

	Rated Capacity (M W)	Gross Generation (GWH)			Gross Heat Rate (BTU/KWH)		
		1979	1980	1981	1979	1980	1981
Gardner 1	150	447.85	672.58	744.84	11,199.	10.698.	10.965.
Gardner 2	200	1,167.29	602.39	973.78	11,081.	11,770.	11,131.
Snyder 1	200	552.58	870.36	634.76	10,895.	12,044.	12,484.
Snyder 2	300	1,101.32	1,061.65	269.74	11,451.	11.887.	13,397.
Malaya 1	300	1,783.07	1,030.77	1,608.01	10,136.	10,467.	10.677.
Malaya 2	350	1,532.57	1,738.31	1,795.19	9,371.	9,566.	9,920.
Tegen 1	100	507.88	582.15	633.32	10,259.	10,162.	10,127.
Tegen 2	100	678.47	529.05	539.40	9,863.	10,075	10,175.
R - 1800	180	690.54	639.31	536.74	11,064	10,904.	11,090.
R - 850	125	226.77	71.97	32.45	13,517	14,282	14,681.
T o t a l s	2,005	8,688.44	7,798.54	7,768.23	10,546	10,778	10,794

d. Forced Outage Rate

	1979	1980	1981	Remarks
Gardner 1	10.8	8.6	12.5	Forced Outage Rate
Gardner 2	13.6	25.0	18.2	$= \frac{\text{Forced Outage Hr}}{\text{Operating Hr + Forced Outage Hr}}\ \%$
Snyder 1	34.8	24.0	33.6	
Snyder 2	20.8	27.6	52.5	
Malaya 1	11.7	21.9	12.1	
Malaya 2	14.8	12.5	6.4	
Tegen 1	11.0	9.6	2.7	
Tegen 2	3.8	8.3	1.2	

e. Major Rehabilitation Activity

(a) 1979

i. Gardner-1

Overhaul, Condenser Retubing, Water Wall Retubing, AH Element Replacement

ii. Snyder-2

Overhaul, RH Retubing, AH Element Replacement

(b) 1980

i. Gardner-2

Overhaul, SH.RH Retubing, AH Element Replacement

ii. Malaya-1

Overhaul, AH Element Replacement, HP Rotor Repair, HPH 6B, LPH 3 Replacement

iii. Malaya-2

Overhaul

iv. GSTP

RO Installation

(c) 1981

i. Snyder-2

Overhaul, 2SH, RH Retubing, MFOP Replacement, HPH By-Pass Installation

ii. Malaya-2

AH Element Replace

(d) 1982

i. Gardner-1

Overhaul, WW Retubing, FDF Replacement, A-AH Element Replacement, SCAH Replacement

ii. Gardner-2

Overhaul, 2SH, RH Retubing, A-AH Element Replacement, HPH By-Pass Installation

iii. Snyder-1 (Plan)

Overhaul, 2SH, RH Retubing, AH Element Replacement, SCAH Replacement, LP Turbine Reblading, LPH-3 Replacement, HPH By-Pass Installation

iv. Snyder-2 (Plan)

Overhaul, HP Rotor Replacement, BFP-T Rebladeing, HPH 5A, 5B Replacement

v. Malaya-1 (Plan)

Overhaul, SH, RH Retubing, LP Turbine Reblading, HPH 5A & 6A Replacement HPH By-Pass Installation

vi. Malaya-2 (Plan)

Overhaul, AH Element Replacement, Condenser Retubing

5.4.2 Further Recommendable Rehabilitation

1) Short Term Rehabilitation Program

a. Reinforcement of Water Quality Control

It is necessary to provide sufficient water quality control instrument and analytical instrument to reinforce the water quality control division. HOH type operation will be applied to the condensate polishing equipment and countermeasures for condenser leak will be provided in order to prevent contamination of feed water.

b. Replacement and Repair of Deteriorated Equipment

Deteriorated equipment which has the highest priority to be amended will be repaired and/or replaced in the next scheduled overhaul and others will be restudied after the overhaul. Engineer will be needed for the rehabilitation program from the planning to the completion of the rehabilitation program including engineering.

(a) Boiler tubes - To be repaired depending on the tube thickness and deposited scale.

(b) Air Heater, Steam Air Heater - To be repaired depending on the deterioration.

(c) Turbine Proper - To confirm guarantee by the Manufacturer on the means of modification.

(d) Condenser, Heater - To repair deteriorated or damaged part.

(e) Generator - Repairing method to be decided by the discussion with the manufacturer.

(f) Automatic Boiler Control - Seeing the result of the S-2 modification, (replacement with Bailey network - 90) to be decided for other "once-through" units.

(g) Local Control and Interlock - To repair, replace or consolidate the items with high priority.

(h) Boiler gas leak should be given perfect repairing.

c. Overhaul Items

At present, boiler and turbine are to be overhauled every year and every 4 years respectively, according to NAPOCOR standard, however, it is actually not followed.

And every four (4) years turbine overhaul seems to involve some problems for the time being.

Therefore, turbines repaired by the rehabilitation overhaul of this time will have to be opened at its upper half casing or at repaired part at next overhaul, and be inspected to decide the overhaul intervals afterwards.

Turbines which was not particularly subjected to any modifications will be opened at its upper half casing or at repaired part 2 years later.

Boiler will have to be inspected every year, especially in case of remarkable deposits and scales inside the boiler tubes. Blowing out should be carried out judging from the turbine side conditions.

d. Overhauling Period

Longer time has been required for overhauling up to the present, and overhaulings are not carried out as scheduled. If the present situation continues as it is, all the thermal power plants will be unavailable. Taking the present situation into consideration, it is strongly requested that all units should be overhauled. Attention should be paid to completion of the repair/inspection works to be carried out during overhauling on schedule.

(a) Strict control of overhauling Schedule

Reinforcement of P & P Group and Invitation of engineering consultants.

(b) Urgent Materials Procurement

Material and equipments required for Rehabilitation Program should be procured as urgent needs, and these should be arranged at earlier stage prior to execution of the overhauling because time of the overhauling depends on the condition of units.

(c) Request of Manufacturer's cooperation to shorten the overhauling period.

(d) Review of Emergency Repair

Emergency repair of defective equipment uncovered additionally during overhauling should be made up to the next overhauling.

(e) Auxiliaries (air compressor, etc.) which can be repaired during normal operation should be repaired by routine works.

Repair works during overhauling should be reduced to allowable work items.

2) Intermediate Term Program

a. Improvement of Equipment

Improvement of equipment regarded as less priority should be performed. The time will be reconsidered after repair works of higher priority are completed.

b. Improvement of Operation Method

Plant operation should be surely supported by operations procedures and operation check sheet.

c. Improvement of Maintenance Method

Not only overhauling but also routine maintenance should be perfectly performed by introduction of highly superior maintenance technic, procedures and check sheets.

3) Long Term Program

a. Review of Maintenance Organization

Smooth and effective overhauling schedule control should be performed by reinforcement of P & P Group, in addition, adoption of subsidiary system should be considered.

b. Establishment of Central Laboratory

Refer to 5.3.3 3).

c. Training

Training for maintenance of instrument and control and mechanical equipments should be especially promoted. With regards to schedule control, maintenance of instrument and control, mechanical and water treatment equipments, NAPOCOR personnel should study foreign technology.

d. Procurement

Standardization of equipment of specifications, adoption of unit price system and prequalification of specified bidder should be reviewed.

e. Reinforcement of engineering capability from the view point of training, personnel rotation should be done and organization should be up-graded.

5.5 TECHNICAL MANAGEMENT OF POWER STATIONS

5.5.1 Stock System of Spare Parts

All of the spare parts for electrical and controls and instruments are stored in the warehouse. These spare parts are stored in the same conditions as that of mechanical spare parts. At least the electronic type spare parts should be stored in a place satisfactorily air-conditioned to avoid moisture and deterioration of insulation.

New spare parts and second hand spare parts are stored in the same place without identification mark and cannot be distinguished clearly and accordingly. Therefore, whole spare parts list should be prepared so as to easily find the spare parts to be replaced and to smoothen the spare parts purchasing program.

Furthermore, all the existing spare parts applicable to each unit should be rechecked whether available at present or already obsolete. If available, the spare parts should be purchased in advance, and if not available, the spare parts should be replaced with new ones in accordance with replacement program of facilities.

With regards to availability of spare parts for instruments and controls, a quantity and number of spare parts are not sufficient for four (4) units in Gardner/Snyder Power Station, especially spare parts for local controls. Controller, gauges and transmitters should be purchased taking the present situation into consideration.

5.5.2 Drawings and Documents

1) Drawings

Drawings related to all the power plant facilities are managed and kept by each section of the power station. However, each section of the power plant has very limited space, and so the drawings are placed disorderly in the shelf of the office. Some of them are in conference room, the others are in another office. In addition to the above, some drawings are difficult to find and some are not legibly clear for reference. These drawings should be gathered in one room for accessibility and serviceability.

The original manufacturers drawings should be managed only by one section in power plant and should be revised at every occasion.

2) Documents

Management conditions of documents are almost same as that of the drawings described above. However, regarding documents management, two serious problems are existing: first, the most important documents for power plant such as specifications and engineering data submitted by manufacturers or suppliers are kept in same conditions as the other documents; second, the important documents are incomplete due to lack of some pages.

To solve these problems, one original document should be kept by one section of power plant, and general use of such kind of documents should be prohibited strictly from borrowing.

3) Operation Data and Records

Operation data and record such as operating summary and operation log books are administered by power plant section in several office rooms here and there. Especially recording charts used in the past are in very bad condition an certain data are already lost. Therefore, it is very hard to check and study past records especially on the date when the trouble occurred. These records and data should be strictly kept for some years to compare or check the past records.

4) Maintenance Records

Maintenance records are administered by each section of power plant. Records regarding major facilities repairs like overhauling of units are prepared by MMRC in cooperation with power plant personnel, and those regarding facilities repairs are prepared only by power plant personnel. But the format of overhauling records should be standardized on all units for ease of comparison with other units. Especially recording format on electrical and control and instruments should be standardized since the control devices are common to all thermal power stations.

5) Efficiency Control

Efficiency and performance tests regarding major facilities are scheduled at following intervals:

	(Existing)	(Recommendable)
a. Heat rate test	1/month	2/year
b. Boiler efficiency test	1/month	2/year
c. Turbine stage efficiency test	2/year	2/year

d.	Boiler performance test	1/month	1/month
e.	Feed water heater performance test	3/year	2/year
f.	Condenser performance test	2/year	2/year
g.	Boiler steam and water circuit pressure check	3/year	3/year
h.	System leak test	1/week	Everyday (after installation of flowmeter)
i.	Generator leak test	4/year	Everyday (Record of consumed bottles)
j.	House service heat exchanger performance test	3/year	3/year
k.	Deep well pump performance test	2/year	1/week (after installation of flowmeter)
l.	Air preheater and steam coil air preheater performance test	1/week	1/week
m.	Generator capability test	1/week	1/week

These test data were carried out at each interval at scheduled up to 1979, and have been kept in relatively good conditions. however, some of the tests listed above have not been carried out since 1980 according to scheduled intervals. These tests should be carried out at the recommended intervals after completion of rehabilitation program.

In addition to the above, these tests should be carried out not only to check and study on performance and efficiencies of the facilities, but also to improve the deteriorated performance, efficiencies and deterioration of the facilities. If these tests were carried out only for tests, it will be meaningless.

And according to past boiler efficiency test records of each unit excluding S-2 unit, the tests were carried out in different generator output conditions. From the viewpoint of comparison and study on deterioration and defectiveness of facilities, boiler efficiency test should be carried out in same operating conditions.

5.5.3 Others

Instruments and Controls Laboratory

Instruments and Controls laboratory is very dirty especially in Gardner/Snyder Power Station, and Instruments for tests are not calibrated precisely. The following instruments for tests are provided in the laboratory.

Pressure tester (2 sets)

Lathe with an electric drill (1 set)

Ohmmeter

Signal generator

Synchroscope

Manometer

Voltmeter

Ammeter

However, testing devices for adjusting and calibration of pneumatic type controllers are temporarily facilitated in the laboratory. Since these devices like control air pressure reducing valves are essentially needed for the calibration of pneumatic controllers, these should be permanently installed in the laboratory.

Electronic type controllers, transmitters and sensors stored in the warehouse at present should be restored in this laboratory for prevention of moisture and deterioration of insulation.

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