h. Associated Substation and Transmission Line

(i) Associated circuit breakers of main transformer are located in another compound such that those of 230 KV are in the compound belong to NLRC (Northern Luzon Region Center) and 115 KV is in the compound of MERALCO.

And the above circuit breakers are controlled at the power plant control room.

(ii) Silicon compound was painted on the 230 KV circuit breakers and disconnecting switches insulators but it seems that thickness is not enough.

Recommendations:

(i) As maintenance schedule is being proposed, proper coordination with MERALCO and NLRC should be done so as to have proper maintenance/overhaul of circuit breakers and disconnecting switches.

(ii) Silicon compound should be painted 0.5 to 1.0 mm thick and should be removed and repainted once a year.

(iii) Thermo-label should be provided on the connection parts of circuit breaker and the connection parts and the contact parts of disconnecting switches in order to monitor the overheating effect.

(iv) Overhead wire and overhead grounding wire should also be checked during shutdown.

(v) In view of less tripping of power plant the following scheme is considered because of frequent tripping due to outside failure.

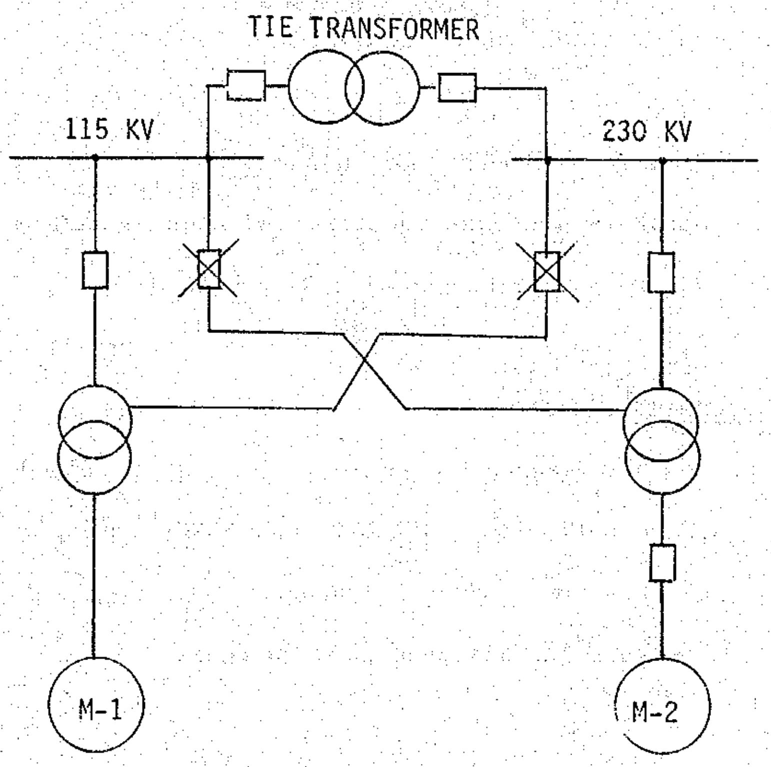


Fig. 5E-35 IMPROVEMENT OF SYSTEM

i. Installation of the system tie transformer

ii. Isolation M-1 from 210 KV bus and M-2 from 115 KV bus

Advantage:

i. To avoid both unit tripping at back-up protection

ii. Easy isolation of M-2 transformer for maintenance

i. Other auxiliaries:

(a) Instrument air compressor and air drier

i. Control air compressor for M-1 and M-2 running in three sets out of four sets existing and M-1 and M-2 air receivers are tied up.

ii. Air dryer for M-1 was overhauled and silicagel was replaced with new one in July 1982, and that of M-2 was newly replaced with higher capacity.

And additional air driers to be installed with existing ones are now under procurement process.

iii. Control air line was oil contaminated due to backflow from fuel line at October 31, 1980, and tank farm and condensate storage tank yard controllers are not working until now.

Recommendations:

i. It seems that capacity of instrument air compressor is a little small but leak check of air line and overhauling of compressor should be carried out first and then condition of operation is same as now, it is recommended to install an additional compressor.

ii. To replace silica-gel periodically.

iii. To replace the contaminated parts/pipings and to put controllers in service as soon as possible.

5.3.2 OPERATION AND MAINTENANCE

JICA team, had stayed in Gardner/Snyder and Malaya Thermal Plants for five weeks to study/improve its rehabilitation program. During our stay, JICA team encountered several times of accidental shut-down and restart-up of the units, and tried to analyze the cause of unit trip, and observed also annual overhaul of Gardner-2. JICA team's observation and investigation have not covered all activities of all operators and all maintenance works, however, JICA team would like to mention JICA observations on operations and maintenance, and measures for improvement.

1) Operation

a. Start-up and shut-down operation

It seems that almost all activities of a start-up and shut-down operation are properly carried out based on the count down activity (standard operation check sheets) in spite of defective control system and equipment/device. Further detailed check sheets like valve operation list before and during the start-up and shut-down operation are now under preparation process.

There were many unit trips due to uncontrollable temperature in the past record. The unit trips occurred several times in a day during start-up. These trips seemed to be due to an improper operation of the start-up by-pass system. Operation of the by-pass system should be done in compliance with the Standard Operation Procedure (SOP).

During start-up or shut-down, there must be a complete coordination between the Operations personnel, and also strict coordination is necessary between control room operators and local auxiliary operators.

For the purpose of this, the SOP should be distributed to each personnel such as boiler, turbine, generator and local operator.

In addition to the above, there is another way by the use of transceivers for cooperative and coordinated operation.

b. Normal Operation

During normal operation, equipment conditions are mainly monitored in the central control room. Observation reveals that monitoring of local equipment and device is not enough due to bad atmospheric condition caused by fuel gas leakage.

c. Operation in faulty condition

JICA team encountered M-1 unit trip. In these case, operator had taken quick actions properly. There seemed to have been no problem, but in order to eliminate faulty operation or to prevent equipment from serious damage, training with the aid of simulator for accident should be performed for the following items as one of the training program.

a) All system black-out

b) All DC power supply failure

c) Instruments air failure

Operation procedure of each item is already prepared. The other item should also be prepared with standard operation procedure.

d. Recommendation concerned to operation

JICA team's observation reveals that the following implementation and improvement are necessary.

(a) To follow strictly to the countdown activity (SOP)

(b) To perform strictly the patrol check for the local equipment twice every shift.

(c) To request fixing defective equipment/device such as valve gland leak noise of motor bearing, mal-indication of local gage, malfunction of local control equipment etc., to the related section in writing.

(d) To check the local equipment condition when alarm is sounded.

(e) To keep the operating condition on the pre-determined value such as pressure and temperature, etc. if there is much difference between the actual and predetermined value, the cause of that must be studied. Especially for Snyder-2 and Malaya-1, strict observance of hydrogen gas pressure to be maintained to 60 psig and load power factor to be maintained within the new characteristic curve should be necessary.

(f) Not to by-pass the plant interlock system without any particular reason.

(g) To indicate abnormal condition on the black board in order to notice the fact to all operators.

(h) To have meeting just after shift change to notice the equipment condition to other operators in detail.

(i) To analyze the cause of trip before restart.

(j) To complete detailed check sheets.

(k) To furnish the standard operation procedure of each local equipment such as seal oil unit, generator cooling water treatment system, etc.

(l) To furnish flow diagram and interlock diagram in the central control room in order to confirm or identify standard operation procedure and the purpose.

(m) To furnish routine operation table.

(n) To indicate optimum value, limit value and alarm point/trip points in the log sheet.

(o) To furnish the standard operation procedure and routine procedure card for individual equipment.

(p) To furnish flash lights and transceiver in the central control room.

2) Maintenance:

a. Routine Maintenance

Defective local control and local gage, small leak of valve gland and draining of sump pit, etc., are seemed to cause serious problem, and these equipments are related to safe plant operation. Only one defectiveness of the above equipments may results in dangerous condition of power plant, therefore, routine maintenance during operation is very important.

b. Recommendation to routine maintenance

(a) To repair the equipment even in slight defective condition (preventive maintenance).

(b) To perform patrol check by maintenance group aside from operation group because the former has enough knowledge regarding equipment defects.

(c) To clean up after maintenance works such as removal of flakes after piping works, parts of equipment not available, etc.

(d) To cut down grass around fuel oil tanks.

(e) To reset the alarm indicators even if it is seemed to have no relation with the plant operation.

(f) To use proper lubricant for motors and pumps.

(g) To carry out replacement of defective parts with the proper materials and tools.

(h) To wipe out the fuel oil and lube oil leakages.

c. Annual overhaul

Annual overhaul should be performed in accordance with Appendix-4, actual operating condition before unit shut-down should be checked strictly. Check items are listed as follows:

(a) To perform the patrol check for all equipments such as bearing temperature of rotating machines, noise vibration, valve gland leak, seat leak, gas and air leak of duct, working condition of local control equipment and also to record the above conditions.

(b) To check spare parts and parts for replacement.

(c) To review manpower and schedule.

During overhauling the following items should be taken cared of:

i. Strict control/management of schedule.

ii. To maintain the environmental condition perfectly clean.

iii. For boiler

(i) To confirm the tube material for retubing

(ii) To cut boiler tube by grinder and to put cap on lower tubes in order to prevent entrance of foreign materials.

(iii) To preheat when alloy steel is whelded (preheating temperature should be 300 to 380°C which can be confirmed by Tempil (thermo crayon)).

iv. For turbine

(i) Lube oil pipe must be capped in order to prevent entrance of foreign material during overhauling.

(ii) To install removable scaffolding in front of condenser manhole.

(iii) To put handrails above the manhole for easy entrance.

(iv) To perform the examination of condenser tube by proper eddy current method.

v. For Safety

(i) Before the job start, explosive and combustible gas must be checked in the boiler.

(ii) To use anti-electric shock type welder.

(iii) To use low voltage (24 V AC) hand lamp in the enclosed vessels.

(iv) To provide helmet for all personnel inside the powerhouse during repair works.

vi. Others

(i) Measurement of alignment should be as follow:

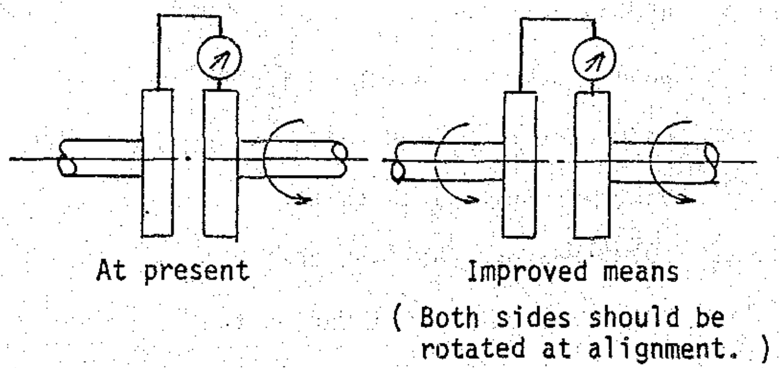


Fig. 5M-36 METHOD OF ALIGNMENT

vii. Qualification of technician

As for welding works (electric arc welding, gas welding, TIG welding, etc.) should be done by qualified technician. NAPOCOR should establish qualification system and perform examination on the basis of unified criterion.

viii. Testing items to be carried out during and after overhauling

During and after overhauling, the following tests and test runs for boiler, turbine and auxiliaries should be carried out and recorded:

* Simulation of combustion and start-up by-pass system controls
* Test run of auxiliaries and equipments
* Measurement of boiler expansion
* Unit capability test and efficiency tests
* Confirmation of boiler safety valve settings
* Hydrostatic test
* Boiler tube radiographic (X-ray) test
* Condenser tube leak test
* Heat exchanger leak test
* LP/HP heater tube leak test
* Generator/turbine vibration test
* Generator hydrogen leak test
* Hydrogen cooler/turbine lube oil cooler leak test

- Generator megger test
- 480V motor megger test
- High voltage motor megger test
- Electrical protective relay test
- Turbine protective device test
- Plant interlock test
- Station service automatic transfer test
- TACC/BACC auto transfer tests
- Emergency equipment auto transfer test

ix. Tools

Major repair of turbine and generator such as journal machining and/or labyrinth groove remachining takes very long time without proper equipment. Adoption of special tools like portable lathe is effective to shorten overhauling period as well as reduction in repair costs, and is recommendable as long as machining accuracy is obtained.

5.3.3 CHEMICAL MANAGEMENT

1) Chemical Laboratory

a. Equipment:

(1) Gardner/Snyder Thermal Power Station

Table 5C-1 shows equipments in the laboratory at GSTP. (These are shown in Report on Technical Services for Improvement of Operations of NAPOCOR Thermal Plants, pp. 2-216 to 2-218.)

The conductivity meter in the plant is not so sensitive for low level analysis due to its higher range. Likewise, one spectrophotometer which is being used for the analysis of chloride, silica, etc. could not be used for trace level analysis because it has only a 10 mm cell. The above apparatus was newly purchased. The atomic absorption spectrophotometer is not being used for the daily water analysis. It is only used for the sludge analysis during the annual inspection of overhauling. There is no attachment for flameless atomizer (graphite furnace atomizer). The said attachment is good for the analysis of low level concentration of sodium. In this regard, if the said attachment is present, the analysis of demineralizer outlet, ammonex effluent, etc., will be easy.

Out of the five (5) sinks in the chemical laboratory, only one is functioning because the other drain lines cannot be used. There are no pure water line in each sink causing inefficiency in laboratory work. The available sink has only condensate sampling line without pure water line.

Table 5C-1 EVALUATION OF THE PRESENT CHEMICAL LABORATORY SET-UP AT GSTP

ACTUAL	REMARKS
o pH Meter 4 sets	
* Zeromatic SS-3 Beckman pH meter x 1	Out of order
* Zeromatic IV pH meter 1	
* Beckman Horizon pH Meter Ecology co, Model 5995 2	Out of order
o Conductivity Meter	
* YSL conductivity bridge Model 31 1 set	This type is obsolete.
* TDS/conductivity analyzer Model 770 1 set	This type is high range. (Minimum range: 0-10 micro S/cm) Addition of conductivity meter with low range. (Minimum range: 0-1 micro S/cm)
o Calorimeter 3 sets	
* Beckman Model DU-2 Spectrophotometer x 1	Out of order
* Beckman Model 35 Spectrophotometer x 1	Have 10 mm cell, only
* Fisher Electrophotometer x 1	This type is obsolete. Beckman Model 35 is the most useful.
o Atomic Absorption Spectrophotometer 1 set	Addition of flameless atomizer attachment in Atomic Absorption Spectrophotometer for sodium ion analysis.
* Perkin Elmer 360 Atomic Absorption Spectrophotometer x 1	
o Direct Reading Balance 2 sets	
* Mattler P 5 N Platform Balance (range: 0.1-5000 g) x 1	

ACTUAL	REMARKS
* Mattler Model B-6 analytical balance x 1 (range: 0.0001-100 g)	Should be put in an enclosed room.
o Calorimeter 1 set	
* Par Adiabatic Calorimeter x 1	
o Kinomatic Viscosity Meter 1 set	
* Fisher/Tag Saybolt Viscosimeter x 1	
o C & H Meter 2 sets	
* Coleman Carbon - Hydrogen Analyzer x 1	Out of order
* Thomas MicroCarbon - Hydrogen Analyzer x 1	
o Others	o Rotary Evaporators for microanalysis Ex. Na^+. Cl^- contents in condensate water o Water Bath ° Water Purifier for laboratory
o Laboratory sink drain lines are out of order, only one is available for use.	For immediate repair. Install also one line of demineralized water to the chemical laboratory for laboratory usage.
o Sampling bottles without caps and improvised rusty wire handle.	Use sampling bottles with caps. On sampling care and proper handling be observed to avoid possible contaminants.

(2) Malaya Thermal Plant

Chemical equipment in the laboratory are shown in Table 5C-2.

- The available conductivity meter is already outmoded. It could not measure trace level analysis.
- The Beckman Model DU-2 spectrophotometer has 20 mm and 100 mm cell so that it is available for trace level analysis of silica and chloride. With regard to silica analysis, it is not so sensitive because its normal wavelength could not be used. The absorbance is fluctuating.
- The atomic absorption spectrophotometer was newly purchased but without flameless atomizer also.
- Out of 9 sinks, only one has available pure water which makes laboratory work inefficient.
- The water distilling apparatus is working well with feedwater from M-1 condensate pump discharge. It is easy to get pure water than GSTP.
- The laboratory apparatus are not enough.

Table 5C-2 EVALUATION OF THE PRESENT CHEMICAL LABORATORY SET-UP (MTP)

ACTUAL	REMARKS
o pH Meter	
* Beckman (Zeromatic)	
* Beckman Century SS-1	Out of order
o Conductivity Meter	Obsolete
* Lab-Line Electro-Mho-Meter	
o Colorimeter	
* Spectronic - 20	
* Fisher Electrophotometer	
* Beckman Mode DU-2 Spectrophotometer	Not available with high wavelength
o Atomic Absorption Spectrophotometer	Addition of flameless atomizer attachment for sodium analysis
* Instrumentation Laboratory aa/ae Spectrophotometer 357	
o Direct Reading Balance	
* Mettler H_2O	
* Mettler P_3	
o Calorimeter	
* Adiabatic Calorimeter	
o Kinetic Viscosity Meter	
* Sayvolt Viscometer	
o Centrifuge	
* IEC HN SII Centrifuge	
o Water Bath	
* Precision Scientific	
o Distilled Water Equipment	
* Barnstead 210 Biopure Distilled Water Center	

b. Water Analysis Method and Frequency:

(1) Gardner/Snyder

Table 5C-3 shows the present water analysis method at GSTP. These analyses are essentially done based on ASTM method. The problems about the method or procedures of analysis are as follows:

- Checking of normality of the titration's reagent and the preservation is important for the measurement of alkalinity. It was observed that the normality for alkalinity analysis is not being checked or standardized. The preservation condition of the reagent is not good as well as other reagents.
- Analysis of chloride is done with Fisher electrophotometer. As mentioned in 1) a. (1), the Fisher method is more sensitive than the spectrophotometer because the latter has only 10 mm cell (Factor with Fisher = 14 vs. Factor with spectrophotometer = 25). The blank solution is usually prepared with mixed bed demineralizer effluent. However, the cation conductivity of the mixed bed effluent frequently increases (sometimes more than 1 micro S/cm), so that the effluent is not always suitable for the blank water. If the cation conductivity of the effluent is 1.2 micro S/cm and it was due only for chloride, the water contains 0.1 ppm chloride. Therefore, when the absorbance of the sample is measured and comparing it to the blank water for reference, the net absorbance will give a smaller value than the correct value. The methods by both Fisher and

spectrophotometer with 10 mm cell are not so sensitive for the trace level analysis of chloride. The detection limit of chloride analysis using Fisher electrophotometer is estimated to be about 0.15 ppm, so that the "0" ppm in the daily water analysis report means less than 0.15 ppm. The preservation condition of reagents it not proper due to its open container which is susceptible to contamination.

- Ammonia is being analyzed by nesslerization method based on ASTM. The accuracy of the said method is affected with the interference of hydrazine.
- pH measurement is done by pH meter. JICA team observed that the sample is being measured without adjusting its temperature. Even if the sample temperature is higher than the standard temperature of 25°C, no adjustment of temperature is done prior to its measurement. The pH in the system water mainly depends on ammonia concentration which is weak electrolyte. The dissociation constant of ammonia changes by the solution temperature as shown in Fig. 5C-1. Therefore, pH in the diluted ammonia solution is affected by the water temperature. This relation is shown in Fig. 5C-2. If the other impurity which affects the pH of solution does not exist, according to Fig. 5C-2, pH of the sample can be estimated at 25°C. Approximately, pH/ T (°C) is shown at about -0.03 (based on 25°C).
- Copper is being analyzed during the neocuproine method. This method includes extraction procedure which is

troublesome, likewise, the pre-treatment is only addition of hydrochloric acid based on the old ASTM. The sample is not being boiled after adding acid while both JIS and new ASTM procedures include boiling after adding acid. The cell being used in the above analysis is below 50 mm cell so that the sensitivity is less and not accurate. The "C" ppm in the report means less than 0.01 ppm copper.

- Silica analysis has similar problems with the chloride analysis. The said problems are the sensitivity and the blank water. Furthermore, the use of pipette made of glass does not give accurate or correct analysis.
- Iron is analyzed with Bathophenanthroline method but is seldom done. The reason for not doing it might be due to troublesome procedure. The sensitivity of analysis is not enough because the instrument has no cell more than 50 mm and also the method of analysis.
- The dissolve oxygen measurement is not being done before. With the guidance of JICA and UTL team, the said analysis is now being done. When JICA team is at GSTP, the said analysis is being done every day. It is observed that when JICA team is not in GSTP no dissolved oxygen analysis is done.
- The analysis for sulfate is not so sensitive too.
- The frequency of main system water analysis is essentially every 4 hours as shown in Table 5C-4 and 5C-5.

- Dissolved oxygen, iron and conductivity analysis are important in the proper evaluation of feed water quality. It was observed that the above items are seldom analyzed. On the contrary, alkalinity which is not so important is analyzed every time.

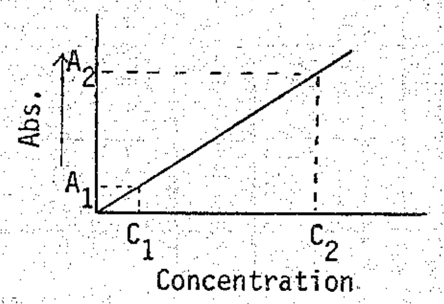
Table 5C-3 EVALUATION OF THE PRESENT WATER ANALYSES METHOD (GSTP)

ITEM	ANALYSIS METHOD	RECOMMENDATION
P - Alkalinity	Titration Method	
M.O. - Alkalinity	Titration Method	
Chloride	Colorimetric, by Fisher (23mm cell), Demineralizer effluent as Blank Factor* 14 (ppm/Abs), 454 mili-micro	by Spectrophotometer with 50 100 mm cell, checking of blank absorbance (confirmation of contamination of reagent or water).
Phosphate	Colorimetic, by Fisher (23 mm cell), Factor=180 (ppm/Abs), 425 mili-micro	by spectrophotometer with 50mm cell
Hydrazine	Colorimetric, by Fisher (23mm cell), Factor=0.9(ppm/Abs), 454 mili-micro	
Ammonia	Colorimetric, Nesslerization Method, by Fisher (23mm cell), Factor=7.3(ppm/Abs), 425 mili-micro	Change to Phenol Method (JIS B8224 3.20.1)
pH	pH Meter - pH changes not properly evaluated. It is affected by temperature variation as indicated by the NH_3 dissociation constant.	Temperature adjustment (- 25°C) or compensation by graph (NH_3-pH - Temp.)
Cu	Colorimetric, Neocuproine Method, by Fisher, Factor=1.4(ppm/Abs), no boiling (old ASTM Method), 454 mili-micro	Change to Zincon Method 50-100mm cell, necessary to boil with acid.

ITEM	ANALYSIS METHOD	RECOMMENDATION
Silica	Colorimetric, Fisher, Factor=3.3(ppm/Abs), 650 mili-micro, Demi Effluent as Blank, use pipettemade of glass	50mm cell, Modification of blank preparation method, pipette made of polythylene, Raw Water = Molybdenum Yellow Method
Fe	Colorimetric, Bathophenanthroline, by Fisher Factor=3(ppm/Abs), 425 mili-micro	Change to TPTZ Method (JIS B8224 3.23.3), 50-100mm cell.
Dissolved Oxygen	Indigo Carmine Method	
Sulfate	Turbidimetric Method, by Fisher, 425 mili-micro, Factor=125, 425 mili-micro	by Spectrophotometer with 50mm cell for low concentration
T-Hardness	Titration Method	
Turbidity	Fisher, 23mm cell, 459 mili-micro,) Factor-200 (ppm/Abs	by Spectrophotometer with 50mm cell

Note:

$$*\text{Factor} = \frac{C_2 - C_1}{A_2 - A_1}$$



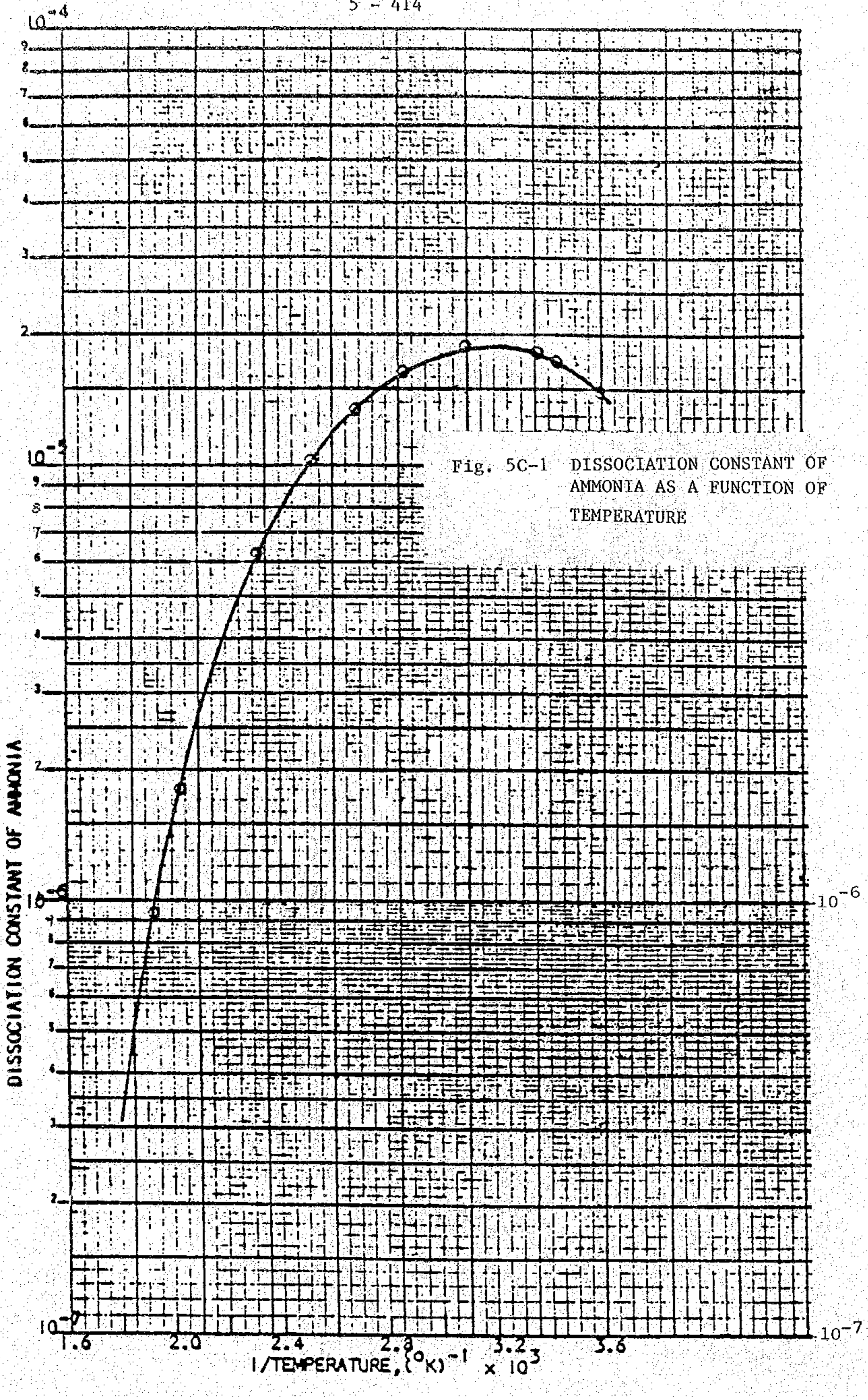


Fig. 5C-1 DISSOCIATION CONSTANT OF AMMONIA AS A FUNCTION OF TEMPERATURE

Fig. 5C-2 THE VARIATION OF SOLUTION PH WITH AMMONIA CONCENTRATION AND SOLUTION TEMPERATURE

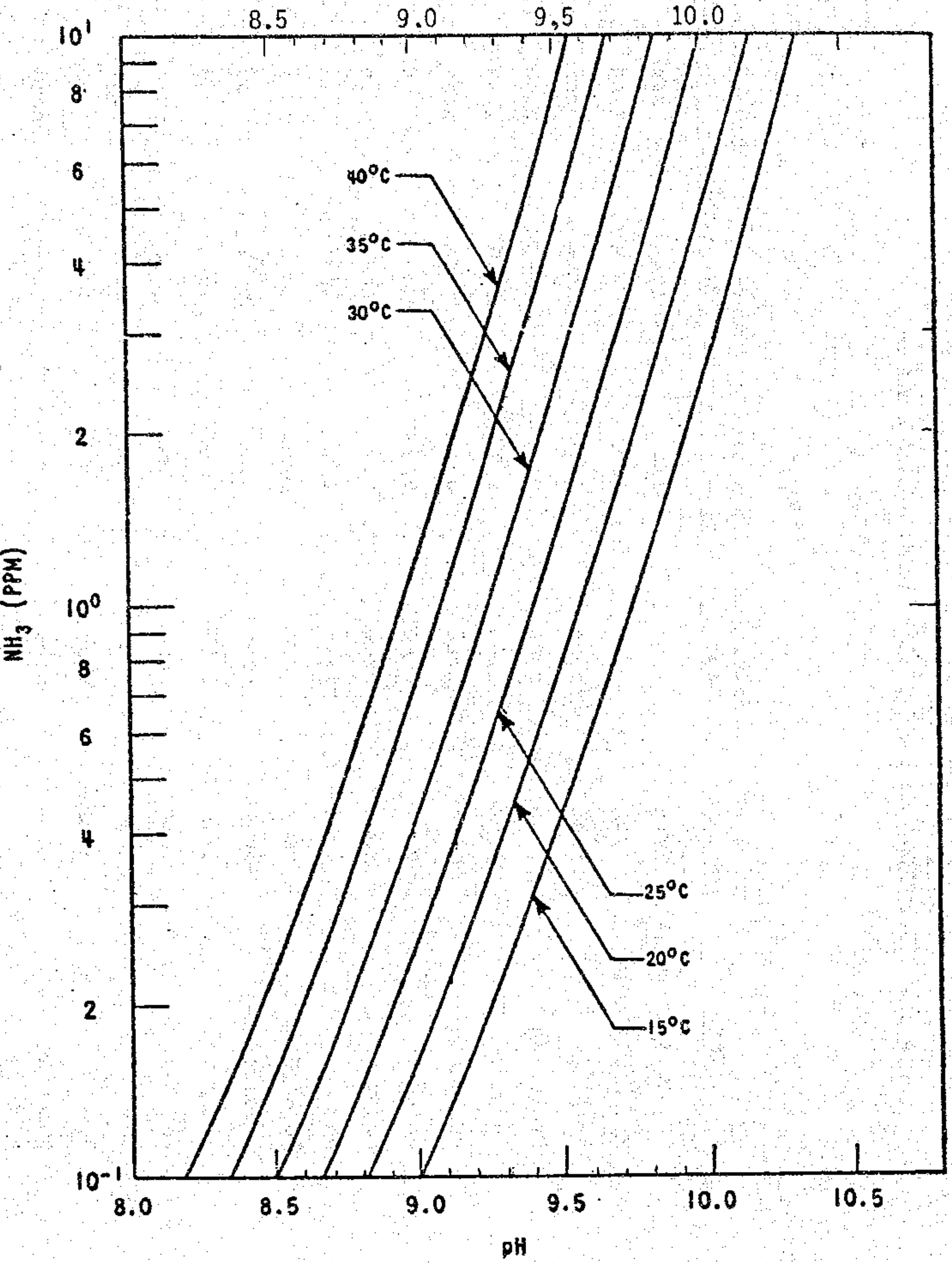


Table 5C-4 FREQUENCY OF MAIN SYSTEM WATER ANALYSIS AT G-1

	Sample				
ITEM	Boiler Saline	Saturated Steam	Superheated Steam	Feedwater Hi-Pressure	Condensate
P. Alkalinity	1/4H	1/4H	1/4H	1/4H	1/4H
M.O. Alkalinity	1/4H	1/4H	1/4H	1/4H	1/4H
Sulfite	none	none	none	none	none
Hydrazine	none	none	none	1/4H	none
Chloride	1/4H	1/4H	1/4H	1/4H	1/4H
Phosphate	1/4H	none	none	none	none
Sulfate	none	none	none	none	none
Hardness	none	none	none	none	none
pH	1/4H	1/4H	1/4H	1/4H	1/4H
Total Solids	none	none	none	none	none
Conductivity	none	none	none	none	none
Silica	1/4H	1/4H	1/4H	1/4H	1/4H
Fe	none	none	none	none	none
Cu	none	none	none	none	none
O_2	none	none	1/D*	1/D*	1/D*
Ammonia	none	none	none	none	none

Note: * by recommendations of JICA & UTL team

Table 5C-5 FREQUENCY OF MAIN SYSTEM WATER ANALYSIS AT S-1, S-2

	Sample			
ITEM	Economizer Inlet	CP Outlet	Individual Effluent	CP Main Steam
P. Alkalinity	1/4H	1/4H	1/4H	1/4H
M.O. Alkalinity	1/4H	1/4H	1/4H	1/4H
Chloride	1/4H	1/4H	1/4H	1/4H
Iron	NONE	NONE	NONE	NONE
Copper	Occasionally	NONE	NONE	NONE
Dissolved Oxygen	1/D*	1/D*	NONE	NONE
Hydrazine	1/4H	NONE	NONE	NONE
Ammonia	Occasionally	NONE	NONE	NONE
Silica	1/4H	1/4H	1/4H	1/4H
Conductivity	NONE	NONE	NONE	NONE
pH	1/4H	1/4H	1/4H	1/4H
Turbidity	NONE	NONE	NONE	NONE

NOTE: * by recommendation of JICA & UTL team

(2) Malaya Themal Plant

Table 5C-6 shows the analysis method for main system water at MTP. Problems about the analysis method are almost similar to GSTP. In case of MTP, the spectrophotometer has 100 mm cell. But the chloride was being analyzed with 20 mm cell. JICA team recommends the use of 100 mm cell in the said analysis.

The frequency of main system water analysis is shown in Table 5C-7. It is almost similar with GSTP, but copper and ammonia is not analyzed.

c. Analytical Reagent:

Almost all reagents are analytical grade, but some are industrial grade. The purchase system of reagents is not consolidated and the management on stocking of reagents is not properly done. On the prepared reagents, the date those were prepared is not written. In this case, the shelf life time is not known.

Table 5C-6 EVALUATION OF THE PRESENT WATER ANALYSES METHOD (MTP) (POINTS DIFFERENT FROM GSTP)

ITEM	ANALYSIS METHOD	RECOMMENDATION
Chloride	Spectrophotometer (Du-2), 20mm cell, Factor=15(ppm/Abs), Factor=2.1 with 100mm cell	100mm cell for low concentration sample (now, used by our recommendation)
Phosphate	Spectrophotometer (Spectronic 20), 10mm cell, A=400 mili-micro, Factor=56(ppm/Abs)	
Silica method	Spectrophotometer (DU-=2), 100mm cell, λ=650 mili-micro, Factor=0.9(ppm/Abs), pipettes, beakers used are made of glass	Use polythylene apparatus, λ=815 mili-micro, Modification of blank preparation
Hydrazine	Spectrophotometer (Spectronic 20), 10mm cell, λ=458 mili-micro, Factor=0.64	
Turbidity	Spectrophotometer (Spectronic 20), 10mm cell, λ=500 mili-micro, Factor=67(ppm/Abs)	Du-2 (100mm cell/20mm cell)
Sulfate	Spectrophotometer (Spectronic 20), 10mm cell, =425 mili-micro, Factor=80(ppm/Abs)	Du-21 (100mm cell/20mm cell)

Table 5C-7 FREQUENCY OF MAIN SYSTEM WATER ANALYSIS AT M-1

	Sample				
Item	Economizer* Inlet	CP Outlet	Ammonex Unit Individual Effluent	Main Steam	Deaerator Outlet
P-Alkalinity	1/4H	1/4H	1/4H	1/4H	1/4H
M.O. Alkalinity	1/4H	1/4H	1/4H	1/4H	1/4H
Chloride	1/4H	1/4H	1/4H	1/4H	1/4H Iron
none	none	none	none	none	
Copper	none	none	none	none	none
Dissolved Oxygen	1/D**	1/D**	none	none	none
Hydrazine	1/4H	none	none	none	none
Ammonia	none	none	none	none	none
Silica	1/4H	1/4H	1/4H	1/4H	1/4H
Conductivity	none	none	none	none	none
pH	1/4H	1/4H	none	none	1/4H

Note: * Economizer data is the same as the deaerator because of No sample flow at the former.

** by recommendation of JICA & UTL team

d. Recommendation:

(1) Equipment

Recommendation points about chemical equipment are shown in Table 5C-8.

(2) Main System Water Analysis Method

- Recommendation points about main system water analysis method are shown in Table 5C-9.
- The analysis method for the trace level of sodium and chloride are as follows:
  - ₒ If the flameless atomizer is attached in the atomic absorption, measurement of sodium is accurate because it has a sensitivity of about 0.01 ppb of the detection level. Without the flameless atomizer, accurate measurement of sodium could be done after concentrating 1000 ml of sample to 100 ml by the rotary evaporator. (This concentrated sample is available to chloride analysis for demineralizer outlet, condensate demineralizer effluent, and other water system samples.) During concentration, contamination of the sample must be avoided. Especially, when the vacuum is broken, inert gas, such as nitrogen or argon should be introduced in the equipment.
  - ₒ Calibration about calorimetric method should be re-checked at least once a year. It is better that the procedure of analysis is written in the calibration table to confirm the procedure of every analysis.

Table 5C-8 RECOMMENDATION FOR LABORATORY EQUIPMENT (GSTP & MTP)

GSTP	MTP
o Purchase of conductivity meter	Ditto
o Purchase of 50 mm cell for spectrophotometer (Beckman Model 35)	Overhauling of spectrophotometer (Beckman Model DV-2)
o Purchase of graphite furnace atomizer for atomic absorption spectrophotometer.	
o Purchase of rotary evaporation equipment for sample concentration. (Available to Na, Cl analysis in demineralizer or condensate polisher effluent, etc.)	
o Purchase of water bath	-
o Purchase of water ultra-purifier (having multi - cartridge mixed resins)	
o Repair of laboratory sink drain line	-
o Increasing of sink having pure water line	-
o Purchase more laboratory apparatus, e.g.; beaker, container, stirrer, pipette, sampling tube, hot plater or heater	
o Purchase of komagome-pipette made of glass and polyethylene, respectively	

Table 5C-9 RECOMMENDATION FOR WATER ANALYSES METHOD

o Alkalinity	o Check normally of titrating reagent (after each preparation)
o Chloride	o Use 50-100 mm cell for low concentration o Check absorbance of blank sample compared to water without reagents. Blank water which the cation conductivity is more than 0.2 micro S/cm should not be used. When the cation conductivity of the blank water is less than 0.2 micro S/cm, and if the absorbance of the blank sample with reagents is more than 0.2 with 50 mm cell, the reagent should be dumped o Avoid contamination of reagents by closing containers
o Silica	o Use 50-100 mm cell for low concentration o Molybdenum Yellow Method for raw water [see Reference - 4, pp. 5-436 to 5-437.] o Use polyethylene apparatus o Modify blank preparation method as follow: (demineralized water — ANSA — Tartaric Acid — Molybdate — HCL ; When tartaric acid exists before adding molybdate, silica-molibdate chelate cannot be formed) When the absorbance of the blank sample prepared by upper method is more than 0.1 at 50 mm cell, the reagents should not be used.
o Phosphate	o Use spectrophotometer with 20-50 mm cell
o Ammonia	o Change to Phenol Method (JIS B8224 3.20.1) [See Reference - 3, pp. 5-433 to 5-436.]
o pH	o Adjust the water temperature to 25° ± 1°C without opening the container o Compensate direct reading by the use of a graph (See Fig. 5C-2)

	o Take pH measurement immediately after getting sample
o Cu	o Change to Zincon Method [see Reference - 2, pp. 5-431 to 5-433.]
o Fe	o Change to TPTZ Method [see Reference - 3, pp. 5-433 to 5-436.]
o Sulfate	o Use spectrophotometer with 50-100 mm cell for low concentration
o Turbidity	o Use spectrophotometer with 50-100 mm cell at 660 micro S for low concentration
o Priority of Analysis Procedure	o Conductivity, pH, NH_3, N_2H_4, Fe, Cu and Si o Use another container for Na, Cl analysis

(3) Frequency of Main System Water Analysis

- Desired frequency and items of main system water analysis is recommended in Table 5C-10 for once-through units, table 5C-11 for drum type units, respectively.
- These are the programs to be followed after the installation of the new sampling rack. Thereafter, when the reliability of the pH, conductivity and cation conductivity monitor are confirmed, the frequency of analysis of these items could be decreased. About the Fe, Cu, SiO_2, O_2, NH_4, Cl^- and Na, when these values change significantly, the frequency of analysis should be increased.
- With the present sampling rack system, Fe, Cu, SiO_2, O_2, NH_4, Cl^- should be analyzed two times frequency as recommended in Table 5C-10 and 5C-11 due to unreliable sampling points and the samples are not representative.

(4) Analytical Reagents

The recommendation points about analytical reagents are as follows:

i. All chemical reagents being used in the analysis should be analytical grade chemical.

ii. All the necessary reagents should be listed including new reagents for the newly added analysis.

iii. The preparation data of the reagent should be written on the container.

iv. The volume of the reagent being prepared should be based on the effective period written in ASTM and the frequency of analysis.

v. The preparation method of reagents should be shown in the form of table.

vi. Intensify stocking control of reagents. Check the consumption and the present stock of reagents every month and keep the proper stock.

Table 5C-10 RECOMMENDATION FOR FREQUENCY OF WATER ANALYSIS AT ONCE THROUGH BOILER

ITEM SAMPLE	pH (at 25°C)	Cond. (uVcm)	Cation Cond. (uV/cm)	Fe (ppb)	Cu (ppb)	SiO_2 (ppb)	O_2 (ppb)	NH_4 (ppm)	N_2H_4 (ppb)	Cl (ppb)	Na (ppb)	Turb (ppm)
Main Condenser at CP Discharge	6/D**	6/D	6/D	2/W***	2/W	1/D	1/D	1/W		3/D	1/D	
Condensate Demineralizer Effluent		6/D*	6/D*	2/W	2/W	6/D	2/W			1/W	1/D	
Deaerator Heater Inlet		6/D							6/D			
Deaerator Tank		1/W										
Economizer Inlet	6/D	6/D	1/D	2/W	2/W	1/D	1/D	1/W	1/D			
Water Wall Outlet	1/D	1/D		2/W	2/W	1/D						1/W
Primary/Roof Super Heater			2/W			2/W				2/W	2/W	
Main Steam	1/D	1/D	1/D	2/W	2/W	1/D		1/W				
Hot Reheat Steam			1/W									
Cold Reheat Steam			1/W									
Flash Tank												
5th Feedwater Heater Drain	1/W	1/W		1/W			2/W					
Auxiliary Condenser	1/D	1/D	1/D	1/W	1/W		1/W			1/W	1/W	

* Conducting at H/OH, Cation Conducting at NH_4/OH

** DAY

*** WEEK

Table 5C-11 RECOMMENDATION FOR FREQUENCY OF WATER ANALYSIS AT DRUM TYPE BOILER

ITEM SAMPLE	pH (at 25°C)	Cond. (uV/cm)	Cation Cond. (uV/cm)	Fe (ppb)	Cu (ppb)	SiO_2 (ppb)	O_2 (ppb)	NH_4 (ppm)	N_2H_6 (ppb)	Cl (ppb)	Na (ppb)	PO_4 (ppm)	Turb (ppm)
Main Condenser at CP Discharge	6/D*	6/D	6/D	2/W**	2/W	1/D	1/D	1/W		3/D	1/D		
Condensate after Heater No. 3		6/D							6/D				
High Pressure Boiler Feedwater	6/D	6/D	6/D	2/W	2/W	1/D		1/W	1/D				
Boiler Saline	6/D	6/D	6/D	2/W	2/W	1/D				3/D	1/D	6/D	1/W
Saturated Steam			1/D			2/W				2/W	2/W		
Main Steam	1/D	1/D	1/D	2/W	2/W	1/D		1/W					
Reheater Outlet			1/W										
Cold Reheater			1/W										
5th Stage Heater Drain	1/W	1/W	1/D	1/W			2/W						

* DAY
** WEEK

ANALYSIS METHOD RECOMMENDED

JIS B-8224 - Testing Methods for Boiler Feedwater and Boiler Water)

Reference - 1. Iron (Fe)

TPTZ-Method

This method is based on the reaction of Fe-ion which is dissolved with hydrochloric acid (HCl) in advance, TPTZ in buffered pH 4 - 5 to blue-colored complex.

In this method, the measuring range is 0.0005 - 0.02 mg in using of cell (longer than 50 mm) and the precision is ± 10 - 3%.

1) Reagents

(a) Water - The water which is used for the test (include reagents dilution water) is to be ion free.

(b) TPTZ-Solution (M/1000)

Dissolve 0.156 g of TPTZ $[(C_5H_4N)_3C_3N]$ in 1 ml of (1 + 1) HCL completely and transfer it to 500 ml volumetric flask and dilute to 500 ml with water.

(c) 10 W/V% Hydroxylamine Hydrochloride Solution

Dissolve 100 g of hydroxylamine hydrochloride ($NH_2OH.HCl$) in water and dilute to 1 liter with water.

** See NOTE.

(d) Ammonium Acetate Buffer Solution

Dissolve 500 g of ammonium acetate (CH_3COONH_4) in water and dilute to 1 liter with water. ** See NOTE.

(e) Iron Standard Solution (1 mg = 0.1 mg Fe^{++})

Dissolve 0.702 g of ferous ammonium sulfate "$FeSO_4(NH_4)_2SO_4.6H_2O$" with water, and 2 ml of (1 + 1) HCl and dilute to 1 liter in a volumetric flask with water.

One (1) ml of this solution contains 0.1 mg of Fe^{++}.

(f) Iron Standard Solution (1 ml - 0.001 Fe^{++})

Pipet 10 ml of iron standard solution (1 ml - 0.1 mg Fe^{++}) into a 1 liter volumetric flask, add 2 ml of (1 + 1) HCl and dilute to 1 liter with water.

One ml of this solution contains 0.001 mg of Fe^{++}.

2) Apparatus

(a) Separatory Funnels 150 - 200 ml

(b) Photometer or Spectrophotometer

Use cells longer than 50 mm.

The containers which have been rinsed sufficiently with iron free water after dipped into (1 + 4) HCl solution for a night are to be used for this test.

3) Procedure

Take 200 ml of sample (it contains less than 0.02 mg of Fe) into 300 ml conical breaker, add 8 ml of HCl and heat. Boil gently down to 20 - 40 ml of volume. After cooling, transfer this solution to a 200 ml volumetric flask with a stopper.

Add 2 ml of hydroxylamine hydrochloride solution and shake sufficiently. Add 30 ml of ammonium acetate solution in order to adjust pH - 4 - 5* and after that, add 5 ml of TPTZ solution and dilute to 100 ml with water.

(*If sample pH is high, adjust pH with HCl solution to 4-5.)

Transfer the colored solution to an absorption cell (longer than 50 mm) and measure the absorbance around wave length of 595 mm in comparison with reference solution which the same procedure has been performed with iron free water.

(Calibration Curve)

Take 0 - 20 ml of iron standard solution (1 ml = 0.001 mg Fe) in series, add 8 ml of HCl and dilute to about 50 ml with water. Add 2 ml of hydroxilamine hydrochloride solution and then, carry out the same procedure as sample.

Make the calibration curve in relation between abrorbance (-log T) and Fe concentration.

NOTE:

The iron (contained in reagents) removal method of 10 W/V% hydroxylamine hydrochloride solution and ammonium acetate solution is as follows:

** Add 5 ml of bathophenanthroline solution (M/400; 0.167 g; dilute to 200 ml by isopropyl alcohol) (add 10 ml of hydroxylamine hydrochloride solution in case of ammonium acetate buffer solution) to 500 ml of the dissolved reagents and shake it.

Transfer it to separatory funnel and add 20 ml of iso-amyl alcohol and shake it for 20 minutes.

Remove colored iso-amyl alcohol zone.

** Repeat above process until iron is removed completely.

** In case of ammonium acetate solution, it is not necessary to add hydroxylamine hydrochloride solution from 2nd times.

** If it is difficult to separate 2 solutions, filter this solution with wetted filter paper.

Reference - 2 Copper - Zincon Method

1) Appreciation

This method can be used for the spectrophotometric determination of soluble copper in water.

Optimum range - 0.0005 - 0.01 mg (using of cell
longer than 50 mm)

Precesion - "10 - 3%

2) Summary of Method

This method is based on the reaction of the soluble copper with zincon to form a blue chilating compound.

3) Reagents

(a) Zincon Solution

Dissolve 0.07 g of Zincon ($HOC_6H_3(SO_3H)$ N: $NC(C_6H_5)$: $NNHC_6H_4COOH$) in 50 ml of methyl alcohol and worm at less than 50°C. Dissolve it with water into 100 ml, and store in a brown bottle.

(b) Ammonium Acetate Solution (50 W/V%)

Dissolve 500 g of Ammonium Acetate (CH_3COONH_4) in water and dilute to 1 liter with water.

(c) Tartaric Acid Solution (1M)

Dissolve 15 g of tartaric acid ($C_4H_6O_6$) in 100 ml of water.

(d) Copper Ion Standard Solution

Dissolve 0.393 g of copper sulfate cryst ($CuSO_4.5H_2O$) in water and add 2 drop of conc. sulfuric acid (H_2SO_4) and dilute with water to one (1) liter.

One (1) ml of this solution contains 0.1 mg of copper ion. Pipet 10 ml of this solution into a 1 liter volumetric flask and dilute to 1 liter with water. One (1) ml of this solution contains 0.001 mg of copper ion.

4) Apparatus

Photoelectric Photometer or Photoelectric Spectrophotometer

5) Procedures

Take 200 ml of the sample taken into a 300 ml conical beaker, add 8 ml of hydrochloric acid and heat. Boil gently down to 20-40 ml of volume.

After cooling, transfer the solution to a 100 ml measuring flask and add 25 ml of Ammonium Acetate solution, 2 ml of tartaric acid solution (1M) in order to adjust pH 3.8 - 4.3.

Then add 0.2 ml Zincon solution and dilute a water to 100 ml. Then transfer it to an absorption cell and measure the absorbance around the wavelength of approximately 600 mili-micron.

absorption cell : longer than 50 mm

Determine the copper content from a pre-determined calibration curve. Perform a blank test through the process and correct the result.

Calibration curve forms the relation between copper content and absorbance by the following method.

Prepare series of copper in standard solution (0 - 10 ml). Add 8 ml of hydrochloric acid and dilute a water to 50 ml.

Then add 25 ml of Ammonium Acetate solution, 2 ml of tartaric acid solution, 2 ml of Zincon solution.

Treat the solution in the same manner as above-mentioned and measure the absorbance.

Reference - 3. Ammonia (NH_4^+) - Phenol Method

1) Reagents

(a) Water -- Pass thru cation exchange resin column, so remove NH_4^+ ion.

(b) E.D.T.A. sol. -- Dissolve 5.0 g of E.D.T.A. in 60 ml of NaOH* solution, and after cooling (until room temperature) dilute with water to 100 ml.

*NaOH solution -- Dissolve 1 g NaOH in 60 ml of water.

(c) Phenol solution -- Dissolve 31.5 g of phenol (C_6H_5OH) in 5 ml of isopropyl alcohol and 10 ml of acetone, and dilute with isopropyl alcohol to total 50 ml. This solution should be adjusted whenever in use.

(d) NaOH solution -- Dissolve 27 g of NaOH with water to 100 ml.

(e) Sodium-phenolate -- Add 20 ml phenol solution (item (c) to 20 ml of NaOH solution (item (d) and dilute with water to 100 ml. Shake it and store in brown bottle. This solution will remain chemically stable for 24 hours.

(f) Sodium hypochloride (available chlorine approximately 1%)

Measure the value of available chlorine of sodium-hypochlorite, and then dilute with water to one (1) % available chlorine contained solution. This solution should be adjusted whenever in use.

(g) Ammonium Ion Standard Solution

Dissolve 2.97 g of NH_4Cl in water and dilute to one liter in a volumetric flask with water. Take 10 ml of this solution and dilute to one liter in a volumetric flask with water. One (1) ml of this solution contains 0.01 mg of NH_4^+ ion. This solution should be adjusted whenever in use.

2) Apparatus - Spectrophotometer

3) Procedure

Take 10 ml of the sample(1) (containing NH_4^+ ion less than 0.045 mg) into a 25 ml measuring cylinder with a stop plug. Add one (1) ml of EDTA(2) and 4 ml of sodiumphenolate. Shake it and add 3 ml of sodiumhypochlorite solution and shake it again. Dilute it with water to 25 ml and shake it. Stand it for about 20 minutes(3) (solution temperature is maintained 20 - 25°C(4)), transfer this solution to an absorption cell and measure the absorbance around the wavelength of approximately 625 milimicron.

Determine the NH_4 content from pre-determined calibration curve. Perform a blank test through the process and correct the result.

Calibration curve forms the relation between NH_4 content and absorbance by the following method.

Prepare a series of NH_4 ion standard solution, treat the solution in the same manner as above-mentioned and measure the absorbance.

NOTE:

(1) In case the sample solution is turbid, sample is filtered through suitable filter paper. (Reject initial 50 ml of filtrate.)

(2) In case the iron ion content is less than 0.15 ppm and copper ion content is less than 0.1 ppm, EDTA solution is not necessary. But in this case, calibration curve without EDTA should be prepared.

(3) The color of this solution is not changed for 20 - 30 minutes after colored.

(4) The time for getting color is varied with the temperature. It should be adjusted at the temperature of calibration curve test.

Reference - 4. Test Method for Silica in Water (for high Silica)

- Silica Molybdenum Yellow Method

1) Summary of Method

The method is based on the measurement of the intensity of the yellow color of the silica-Molybdenum complex with a pH of 1.2 to 1.5.

Analytical Scope: 0.5 - 4.0 mg

Precesion : ± 10 - 2%

2) Reagents

(a) Ammonium Molybdate Solution (10 W/V%)

Dissolve 21.2 g of ammonium molybdate $[(NH_4)_6MO_7O_{24}.4H_2O]$ in water and dilute to 200 ml. This solution is available for a week.

(b) Tartaric Acid (10 W/V%)

Dissolve 10 g of tartaric acid $[(C_2H_2(OH)_2(COOH)_2]$ in water and dilute to 100 ml.

(c) Silica Standard Solution (1 ml - 1 mg SiO_2)

Dissolve 4.732 g of sodium metasilicate ($Na_2SiO_3.9H_2O$) in water and dilute to one (1) liter. Check the concentration of this solution in accordance with gravimetric method.

3) Apparatus

Photoelectric photometer or Photoelectric spectrophotometer.

4) Procedure

Add 2 ml of ammonium molybdate solution (10 W/V%) and one (1) ml of hydrochloric acid (5 + 4) to 50 ml of the sample taken at the approximate temperature of 25°C containing 0.5 - 4 mg of SiO_2.

Mix well, immediately. Stand it for 10 minutes and add 2 - 6 ml of tartaric acid (10 W/V%). Mix well. Immediately transfer the solution to an absorption cell and measure the absorbance around the wavelength of 410 - 450 mili-micron. Determine the silica concentration in comparison with predetermined calibration curve and calculate ppm of silica. Calibration curve shows the relation between silica concentration and absorbance being formed as follows.

Prepare a series of silica standard solution from 0 to 4 ml and dissolve with water into 50 ml and treat the series in the above-mentioned manner.

NOTE:

** If the sample does not contain phosphate, addition of tartaric acid is not necessary. In case of adding tartaric acid, color increasing of silica - molybdenum stops, so that, the holding time after that should be kept strictly.

2) Water Quality Management

a. Daily Laboratory Analysis Data

Typical data of daily laboratory analysis at GSTP (Gardner-1, Snyder-1, Snyder-2) and MTP (Malaya-1 and 2) is shown in Table 5C-12. From the data, it shows frequent analysis of alkalinity, but alkalinity is not of great importance in our control of water quality. Chloride concentration in almost all analysis is "0" ppm except for boiler saline. The reason that the detection limit is high is the problem about the blank water and the sensitivity of the analysis. As a result of it, the data of chloride has the possibility of giving false judgement about the water quality. The unit of chloride at GSTP is expressed as NaCl and it is difficult to understand.

Phosphate concentration in boiler saline is frequently out of specification/limit. pH values of samples at higher temperature are unrealistic. For sample, at Snyder, pH of 9.4 in economizer inlet corresponds to 9.7 at 25°C, so that it exceeds extremely the upper limit. The effect of that to the system is known very well. It is difficult to understand that the specification (see Reference - 5) of pH in the boiler saline at Malaya-2 is between 0.5 and 10.0. Phosphate concentration in the boiler saline is 1 - 3 ppm and the Na/PO_4 molar ratio is 2.5 - 2.6. pH value must be less than 9.5 (see Fig. 5C-3). It is understood, like in cases of boilers having the pressure more than 150 kg/cm^2, it is dangerous that the pH in the boiler water is controlled beyond 9.5. As observed in silica analysis, shown in the silica data, preparation method of the blank is not reliable and also the sensitivity of analysis as well as chloride. The true concentration is considered to be higher than the recorded data. The specification of silica (see Reference - 5) in boiler saline at M-2 is less than 0.3 ppm, but this value is evaluated to be high in preventing carry-over of silica to the steam. In Japan, the specification is less than 0.2 ppm.

Copper is "0" ppm at GSTP. It is not reliable because of the problem of the pre-treatment and the sensitivity of the analysis. As mentioned earlier, the pretreatment is only hydrochloric acid addition, so that, metallic copper or some kind of oxide cannot be perfectly dissolved. This is one reason why this method gives smaller or lower values. It is considered that the detection limit of this analysis method may be about 0.01 ppm.

Ammonia is analyzed by ASTM method, but this analysis is not also reliable because of the effect of hydrazine that cannot be avoided. Also, temperature of the sample is higher than the desired.

Measurement of the dissolved oxygen in the water system is very important especially in the prevention of system materials corrosion, but until now little has been done. Enforcement of rigid dissolved oxygen control was recommended by the JICA and UTL team. During the survey of JICA team, some data were gathered.

The important analysis, such as, conductivity, cation conductivity, iron and sodium were not religiously done.

b. Analysis Data By JICA team

Conductivity and pH meter were brought into the laboratory at GSTP and MTP for the survey of water quality by JICA team. These survey data is shown in Table 5C-13, 14. Except for the pH at MTP, the measured pH at the sample temperature is different from the pH at 25°C, because of the high temperature of sample. The function of the temperature compensator in the pH meter is only for the compensation of the electric potential with the temperature and does not include the compensation for the change in the dissociation constant of the electrolyte in the water solution with the temperature. In case of the diluted ammonia solution, pH/ T(°C) is about -0.03, so that the effect cannot be neglected. This effect is already explained in 5.3.3.1) b. The relation between pH and temperature is shown in Figure 5C-2. The compensated pH at 25°C is shown in Table 5C-13, -14, also. The relation between the pH of ammonia solution and the conductivity is shown in Figure 5C-4. The pH at 25°C corresponds to the conductivity, very well. The pH of the system water at GSTP is very high and out of specification*. In case of MTP, measurement of the pH was done with the pH meter at the laboratory. The pH at 25°C doesn't correspond to the conductivity at MTP. It is difficult to conclude the cause. If the conductivity is right, the pH in the feedwater at M-1 is about 9.1 and lower than the lowest specification value (see Reference - 5).

The cation conductivity of the condensate and feedwater of all units were higher than the maximum allowable limit* of 0.3 micro S/cm specification.

It was observed that the influent and effluent of the condensate polisher have high conductivity readings (after passing thru cation resin) which is more than 0.3 micro S/cm. Our experience in Japan, a conductivity reading more than 0.3 micro S/cm indicates presence of condenser leakage. Anion content in the sample can be understood relatively by the measurement of the cation conductivity. If the anionic impurity in the sample is only chloride, the relation between the cation conductivity and chloride is shown in Fig. 5C-5. Namely, chloride concentration is shown in the following equation, approximately.

$$\text{chloride (ppm)} = (\text{cation conductivity})/12$$

The cation conductivity in the boiler saline at M-2 is significantly high (59 micro S/cm) for the condenser in leakage, as shown in Figure 5C-14. The chloride concentration can be calculated from the cation conductivity, because the phosphate is analyzed. It is given as follows:

$$\text{Chloride(ppm)} = \frac{(\text{Cation Conductivity}) - 2.2 \times \text{PO}_4(\text{ppm})}{12}$$

PO_4(ppm) in the boiler saline at M-2 on August 27 is about 2. Therefore, chloride is calculated as follows.

$$\text{Chloride (ppm)} = \frac{59 - 2.2 \times 2}{12} = 4.6 \text{ ppm}$$

The observed chloride concentration is about 5 ppm almost the same as the calculated value. Anyway, by this survey, the specification (see Reference - 5) of the system water quality for both GSTP and MTP on the points of pH and cation conductivity were not satisfactory.

c. Evaluation on the Detection Limit of the Water Analysis

In Table 5C-15, the detection limits of chloride, silica, copper, iron and sulfate were estimated based on the actual method. The table includes the required limits. The detection limits of almost all items were relatively high, so that, it is difficult to give evaluation whether to keep the water quality specification or not.

d. Water Quality during Condenser in Leakage

Figure 5C-6 shows the results of sodium monitors for the condensate pump discharge, ammonex outlet and the conductivity meter for the condensate pump discharge set by JICA team during condenser in-leakage at Snyder-1 on 16th of August. These chart shows the typical sign of the condenser in-leakage. It is certified that the monitoring of sodium and cation conductivity in the condensate is very effective for the rapid detection of condenser in-leakage. This condenser in-leakage was temporary controlled by means of charging sawdust.

Figure 5C-7 shows the behavior of the chloride, cation conductivity in CPD and the chloride in boiler at M-2 on the latter part of August. Monitoring of the cation conductivity in the condensate is shown to be effective in the detection of condenser in-leakage, on this unit. According to the survey at M-1 by UTL team on the 14th of August, the cation conductivity is about 16 micro S/cm. This corresponds to the analyzed chloride concentration of 1.3 ppm.

e. Dissolved Oxygen Control

As mentioned before, the measurement of dissolved oxygen in the system water was hardly done. By the recommendation of JICA and UTL team, some data were gathered. These data is shown in Table 5C-16.

At GSTP, all units have high D-O_2. This can be attributed to the technique/air contamination during sampling and air in-leakage in the condenser system. The rate of chemical deaeration with hydrazine is relatively slow at low temperature. With high dissolved oxygen in the condensate, oxygen is almost impossible to prevent going into the boiler. It gives harmful effect to the system material. On the contrary, the dissolved oxygen at MTP is almost zero, just like in Japan.

f. Behavior of Impurities (Cl, SiO_2) in Boiler Saline

Figure 5C-8 shows the behavior of chloride and silica in the boiler drum at Gardner-1 during 1st-24th of August. The feedwater flow rate vary a little as shown in the figure but the blowdown rate of the drum is constant. Therefore, if amounts of the chloride and silica going into the boiler is constant, these concentration in the boiler saline would be approximately proportional to the feedwater flow rate. Nevertheless, these concentration does not correspond to the feedwater flow rate, and changes remarkably. The reason considered are as follows:

- The problem on the accuracy of the analysis
- Inaccuracy of the measurement of the blowdown rate
- Variation of carry-over to the steam
- Variation on the amounts of impurities going into the drum

Based on the enumerated reasons, the possibility of the first three (3) items are not remarkable but the last reason can be considered with the most possibility. Chloride behavior does not correspond to the silica, so that the most reasonable explanation cannot be found out, at this time.

g. Form of the Daily Report

Power station has the daily water analysis report on every unit. Many daily reports are being used, numbering 10 to 15 sheets for every stations.

h. Recommendation about Water Chemistry Control

(a) Keep up with the water quality specification

i. pH, hydrazine, phosphate and Na/PO_4 molar ratio should be kept strictly. (accurate analysis must always be done).

ii. When dissolved oxygen, SiO_2 and cation conductivity became out of specification, rapid inspection must be done to recover from the abnormal condition.

Dissolved oxygen: inspection around condenser system

SiO_2: inspection of make-up water system and condensate demineralizer

Cation conductivity: inspection about condenser in-leakage, demineralizer and condensate demineralizer

iii. Water chemistry control of the drum water

v) Keep of Na/PO_4 molar ratio. (Confirm molar ratio by the analysis of sodium everyday)

vv) Intensification of the blowdown (when the impurities is more than specification, the blowdown rate should be increased.)

(b) Reestimation of the specifications of the water quality

i. Verify 9.5 - 10.0 of pH limit of boiler saline for M-2 to Hitachi. JICA Team recommends 9.0 - 9.5 of pH.

ii. SiO_2 in the boiler saline at M-2 should be less than 0.2 ppm.

(c) Possible modification of water chemistry control

i. Increasing hydrazine concentration. When the unit has high dissolved oxygen in the condensate or feedwater, hydrazine concentration should be kept more than 2 times of the DO_2 concentration. If the hydrazine concentration is increased, the ammonia injection rate must be decreased, because of the pH increase by the decomposition of hydrazine to ammonia. Generally, for the practice, the test on the water chemistry con-