trol must be performed actually on the unit and the suitable chemical injection rate must be decided.

ii. Change to All Volatile Treatment for drum water treatment. When phosphate is used for the drum water treatment, it is possible that the boiler tube will be attacked by the free caustic. To avoid such condition, Kyushu Electric Power Co. adopts all volatile treatment (AVT) even in the case of the drum type boiler and prevents the damage of material by the water quality. In the adoption of AVT, first the frequency of condenser in-leakage must be minimized.

(d) Making of monthly report about water analysis (See Table 5C-17)

As an elemental data for monthly report, daily analysis data on every items shall be recorded through one month period. It can be used for checking purposes.

Table 5C-12 DAILY WATER ANALYSIS REPORT AT GSTP & MALAYA (EXAMPLE) August 1982

Sample Location	Economizer Inlet (Feedwater Hi-Pressure)					Condensate Pump Outlet					Ammonex Outlet			Main Steam		Boiler Saline		Saturated Steam		Super Heated Steam
Unit	G-1	S-1	S-2	M-1	M-2	G-1	S-1	S-2	M-1	M-2	S-1	S-2	M-1	S-1	S-2	G-1	M-2	G-1	M-2	G-1
P. Alkalinity $CaCO_3$	1~2	1~5	3~5	~2		~1	2~5	4~8	~2		1~2	2~3	~2	1~3	~4	3~5		~1		~1
M.O. Alkalinity $CaCO_3$	4~7	6~10	7~12	~7		4~6	7~10	10~14	~7		4~6	7~8	~7	6~10	7~11	7~12		4~6		4~6
Hydrazine ppm as N_2H_4	0.02 ~0.04	0.03 ~0.05	0.01 ~0.03	0.03 ~0.05	0.02 ~0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chlorides ppm as NaCl	~0	~0	~0	~0	0~1	~0	~0	~0	~0	0~1	~0	~0	~0	~0	~0	0~1	2.9 5.7	~0	~0	~0
Phosphate ppm as PO_4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1~8	2~3	—	—	—
pH	8.2 ~8.6	8.6 ~9.4	8.9 ~9.3	9.0 ~9.2	8.7 ~9.2	8.7 ~9.1	8.9 ~9.2	9.2 ~9.4	8.2 ~8.9	8.3 ~9.0	8.4 ~8.8	8.3 ~8.7	—	8.8 ~9.4	8.9 ~9.2	8.5 ~9.1	9.4 9.5	~8.5	~9.0	~8.5
Silica ppm as SiO_2	~0.01	~0.007	~0.007	~0.008	0.01 ~0.03	~0.01	~0.007	~0.007	~0.009	0.02 ~0.03	~0.005	~0.006	~0.008	~0.005	~0.006	0.2 ~3	0.2 0.3	~0.009	~0.01	~0.009
Copper ppm as Cu	~0	~0	~0	—	—	—	—	~0	—	—	—	—	—	—	—	—	—	—	—	—
Ammonia ppm as NH_3	—	0.5 ~1.7	~1.8	—	—	—	~1.0	~1.6	—	—	—	—	—	—	—	—	—	—	—	—
Dissolved Oxygen ppb as O	10 ~50	5 ~20	10 ~20	~0	~0	20 ~80	5 ~40	20 ~60	~0	~0	—	—	—	—	~15	—	—	—	—	—

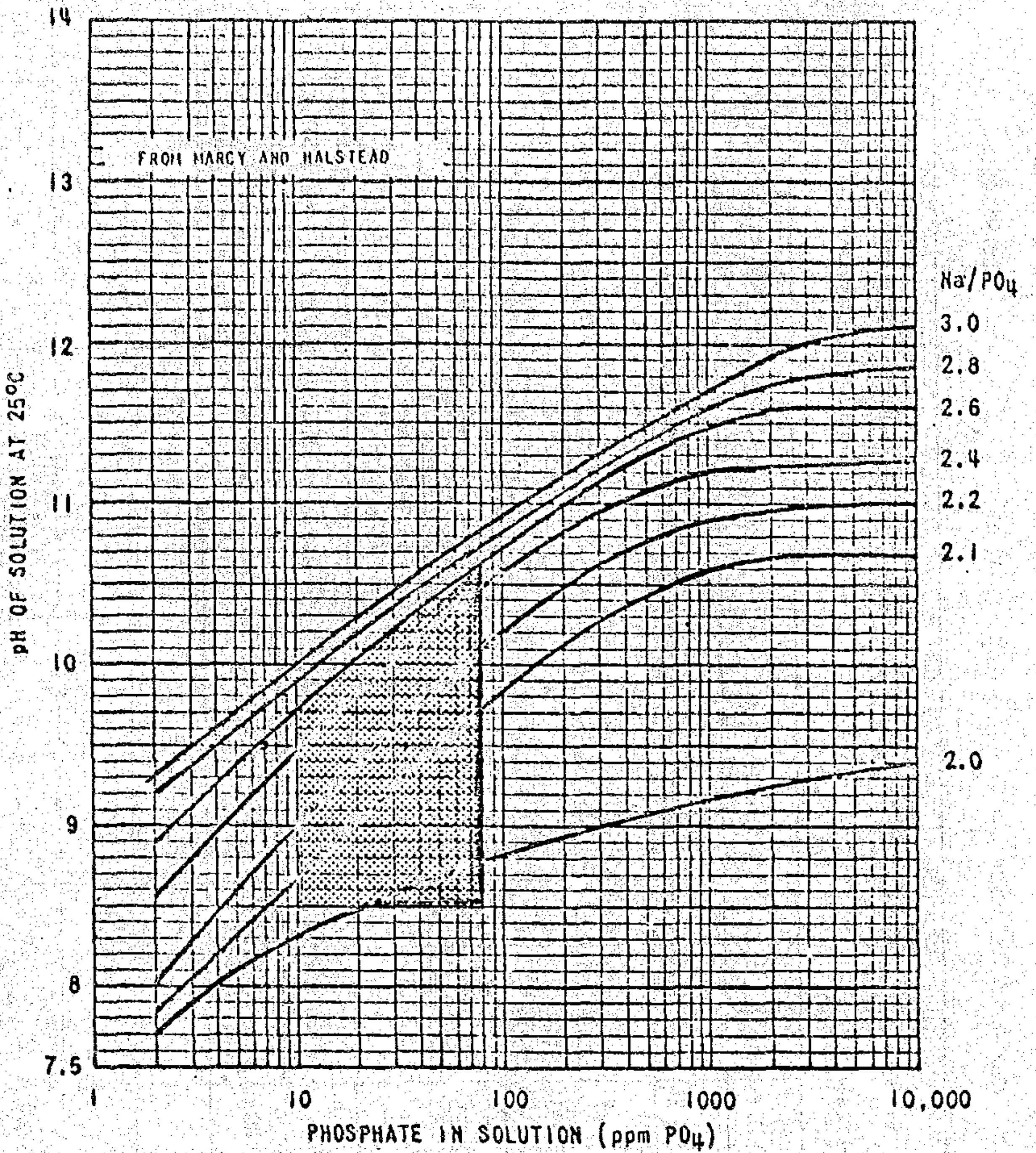


Fig. 5C-3 PH OF ORTHOPHOSPHATE SOLUTIONS HAVING VARIOUS MOL RATIOS OF SODIUM TO PHOSPHATE

Table 5C-13 SYSTEM ANALYSES DATA DONE BY JICA TEAM

(Gardner/Snyder)

Unit	Sample	Time	pH*	Cond. (μS/cm)	Cation Cond. (μS/cm)	Fe (ppb)	Temp. (°C)
S-1	Condensate	Aug. 10	9.3/9.6	9.45	0.83		36
S-2	Condensate	Aug. 10	9.25/ 9.55	8.53	0.45		36
S-1	Condensate	Aug. 11	9.35/ 9.65	10.8	0.85		35
S-2	Condensate	Aug. 11	9.3/ 9.6	10.1	0.41		35
G-1	Condensate	Aug. 11		5.6	0.92		
G-1	Superheated Steam	Aug. 11		5.7	0.95		
G-1	Saturated Steam	Aug. 11		5.8	0.87 ~0.98		
S-1	Ammonex A	Aug. 11		9.8	0.50		
S-1	Ammonex B	Aug. 11		0.58	0.62		
S-2	Ammonex A	Aug. 11		10.2	0.43		
S-2	Ammonex B	Aug. 11		10.2	0.43		
S-2	Ammonex C	Aug. 11		6.2	0.39		
S-1	Condensate	Aug. 12	9.45/ 9.75	13.0	0.99		35
S-2	Condensate	Aug. 12	9.40/ 9.70	12.5	0.33		34
S-1	Condensate	Aug. 13	9.4/9.7	12.0	1.0		36
S-2	Condensate	Aug. 13	9.1/9.4	6.2	0.32		36

* left/right = at sample temp / at 25°C (by graph)

Table 5C-13 SYSTEM ANALYSES DATA DONE BY JICA TEAM

(Gardner/Snyder)

Unit	Sample	Time	pH*	Cond. (μS/cm)	Cation Cond. (μS/cm)	Fe (ppb)	Temp (°C)
S-1	Condensate	Aug. 17		9.5	0.34		
S-2	Condensate	Aug. 17		7.2	0.31		
G-1	Condensate	Aug. 18	8.55/9.1	3.5	0.66		48
G-1	Superheated Steam	Aug. 18	8.8/9.1	3.6	0.81		37
G-1	Saturated Steam	Aug. 18	8.85/9.15	3.9	0.65		37
G-1	Boiler Saline	Aug. 18	9.3/	18.0	13.0		35
S-1	Condensate	Aug. 18	9.6/9.9	19.0	0.70		34
S-1	Ammonex B	Aug. 18	9.2/9.9	19.0	0.89		47
S-1	Ammonex C	Aug. 18	9.2/9.9	19.0	0.65		47
S-1	Main Steam	Aug. 18	9.2/9.9	17.4	0.91		45
S-2	Condensate	Aug. 18	9.35/9.65	11.0	0.37		36
S-2	Ammonex B	Aug. 18	8.9/9.6	9.0	0.46		52
S-2	Ammonex C	Aug. 18	8.9/9.6	9.0	0.45		51
S-2	Ammonex D	Aug. 18	8.9/9.5	8.8	0.72		45
S-1	Condensate	Aug. 20	9.4/9.7	12.0	0.90		35
G-1	Feedwater	Aug. 23				12	
S-1	Eco Inlet	Aug. 23				20	
S-1	Condensate	Aug. 23				5	
S-2	Eco Inlet	Aug. 23				4	

* left/right = at sample temp/at 25°C (by graph)

Table 5C-13 SYSTEM ANALYSES DATA DONE BY JICA TEAM

Unit	Sample	Time	pH*	Cond. (μS/cm)	Cation Cond. (μS/cm)	Fe (ppb)	Temp (°C)
G-1	Feedwater	Sept. 3	8.8**			8**	
G-1	Condensate	Sept. 3	8.2**			10**	
S-1	Condensate	Sept. 9	9.3/9.6 (9.1)**	10.5	0.55		33
S-2	Condensate	Sept. 9	9.1/9.4 (8.7)**	7.3	0.38		33
S-1	Condensate	Sept. 9***			0.45		33
S-1	Ammonex B	Sept. 9***		0.19	0.28		53
S-1	Ammonex C	Sept. 9***		0.70	0.70		53

* left/right = at sample temp/at 25°C

** by NAPOCOR (Fe analysis = TPTZ Method)

*** just after H/OH operation of all ammonexs

Table 5C-14 SYSTEM ANALYSES DATA DONE BY JICA TEAM (MALAYA)

Unit	Sample	Time	pH*	Cond. (μS/cm)	Cation Cond. (μS/cm)	Temp. (°C)
M-1	Condensate	Aug. 24	8.6/8.9	3.2	0.51	35
M-1	Deaerator Outlet	Aug. 24	8.0/8.3 (8.0)**	2.8	0.46	35
M-1	Ammonex A	Aug. 24		0.38	0.41	40
M-1	Ammonex B	Aug. 24		0.51	0.66	41
M-1	Ammonex C	Aug. 24		0.22	0.32	41
M-1	Ammonex D	Aug. 24		0.33	0.50	42
M-1	Condensate	Aug. 25		1.8	0.49	
M-1	Deaerator Outlet	Aug. 25		2.3	0.36	
M-2	CP Discharge	Aug. 27		3.1	1.6	23
M-2	Eco Inlet	Aug. 27		2.7		
M-2	Boiler Saline	Aug. 27		19	59	
M-1	Deaerator Outlet	Sept. 1			0.55	
M-1	CP Discharge			3.5	0.50	

* left/right = at sample temp/at 25°C

** Monitor

Fig. 5C-4 VARIATION OF SOLUTION PH AND ELECTRICAL CONDUCTIVITY WITH AMMONIA CONCENTRATION AT 25°C

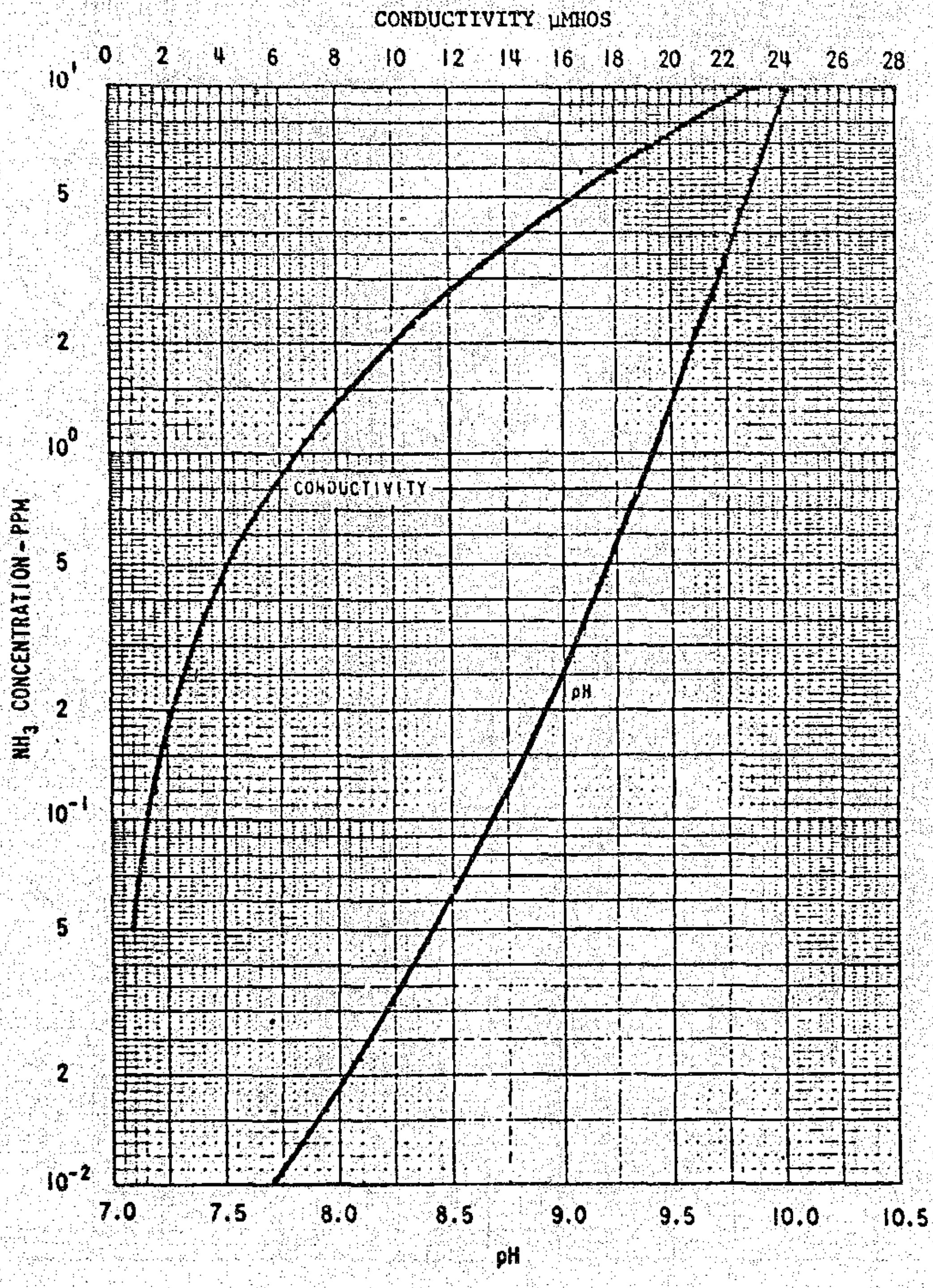


Fig. 5C-5 CHLORIDE VS. CATION CONDUCTIVITY BY CALCULATION

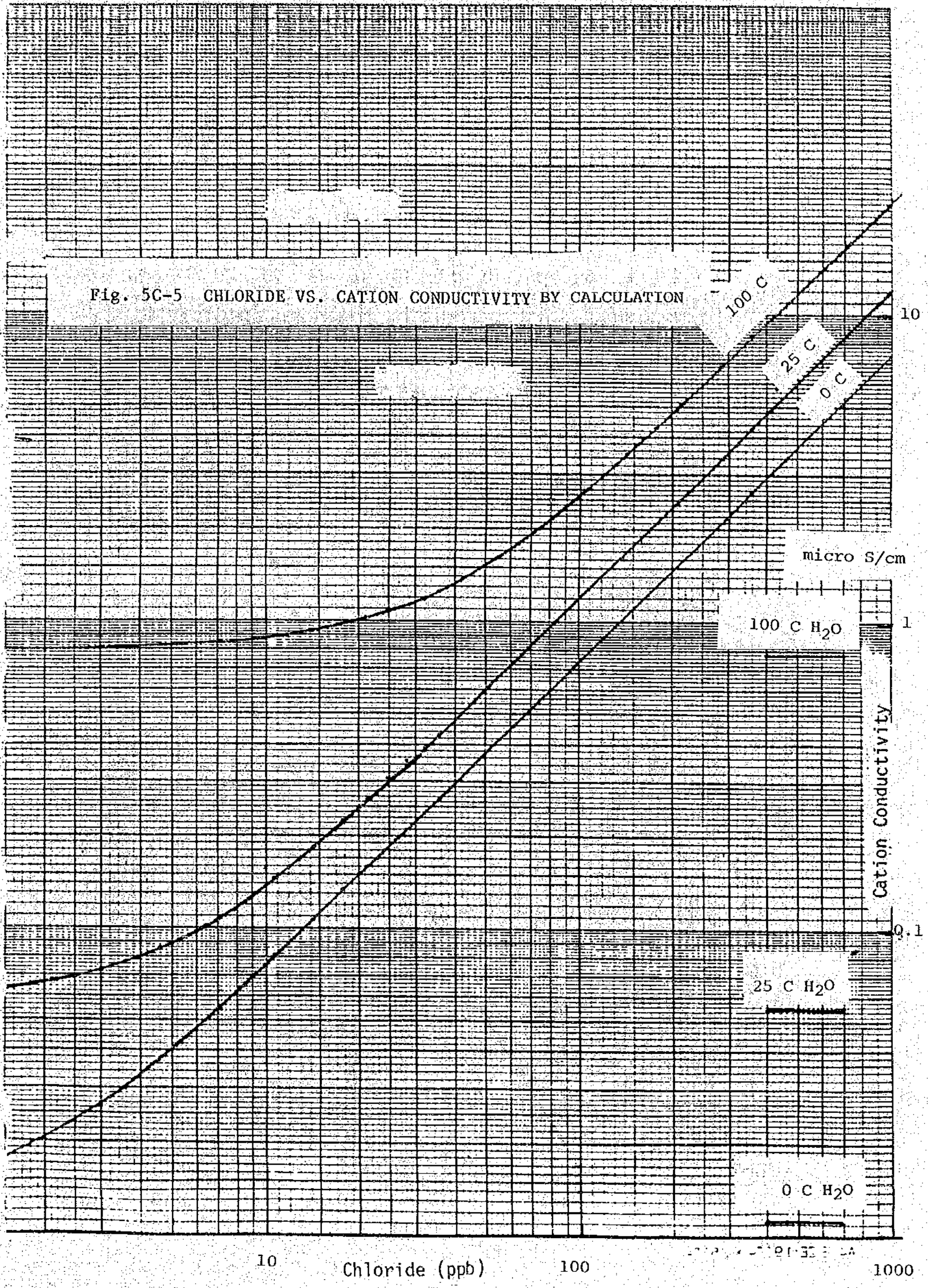


Table 5C-15 DETECTION LIMIT OF WATER ANALYSIS AT GSTP AND MTP

ITEM	ACTUAL		REQUIRED
	GSTP	MTP	
Chloride (ppm as Cl)	0.1～ 0.2	0.1～0.2 with 20mm cell 0.02～0.04 with 100mm cell	<0.02
Silica (ppm as SiO_2)	0.03～0.05	0.02～0.04	<0.02
Sulfate (ppm as SO_4)	1～2	0.5～1.0	–
Copper (ppm as Cu)	0.005～0.01	------	<0.002
Iron (ppm as Fe)	0.02～0.04	------	<0.01

Fig. 5C-6 Na AND CATION CONDUCTIVITY AT SNYDER-1

CONDENSATE DURING CONDENSER IN-LEAKAGE

(August 16, 1982)

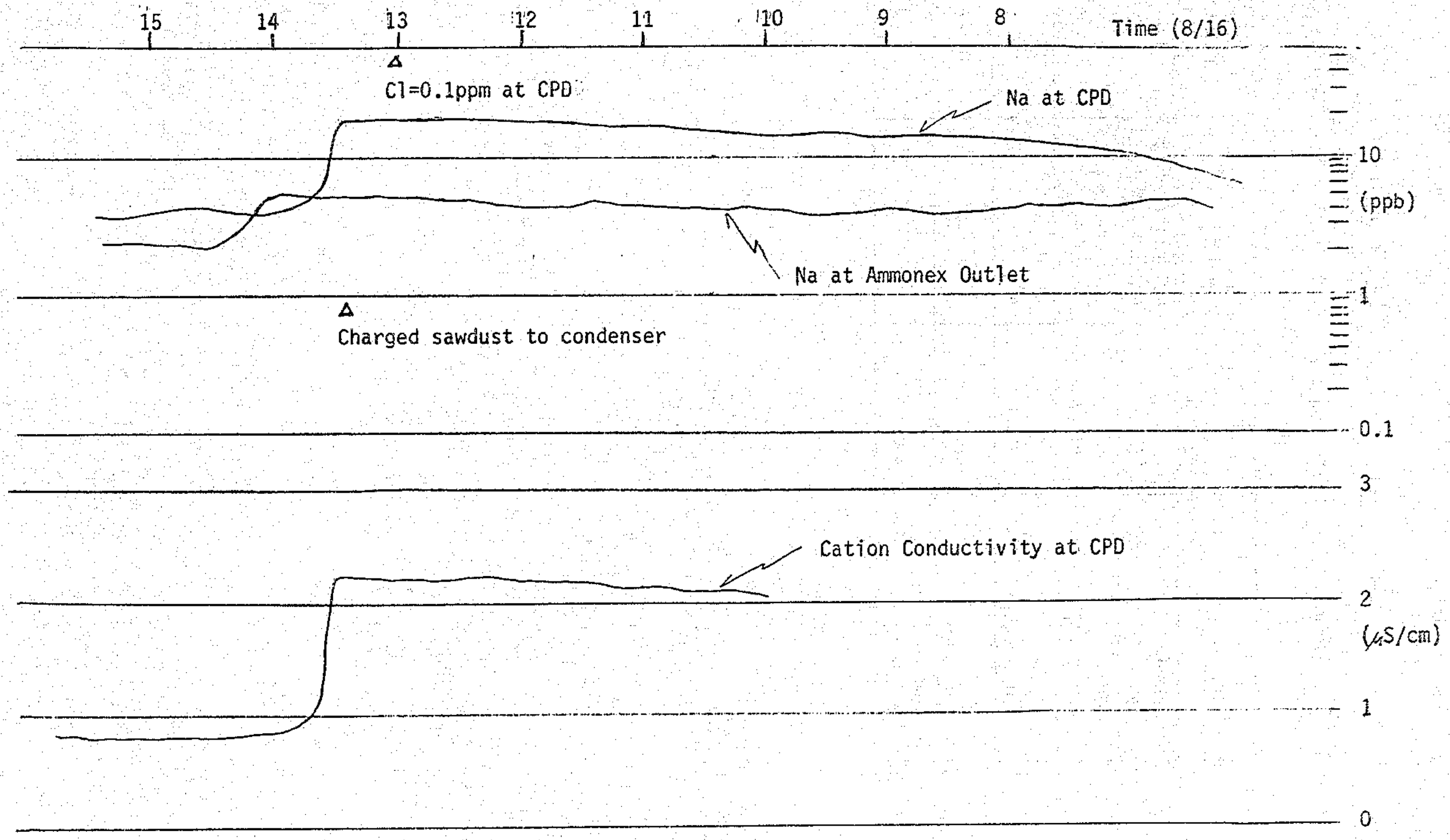


Fig. 5C-7 WATER QUALITY AT MALAYA-2 DURING CONDENSER LEAKAGE

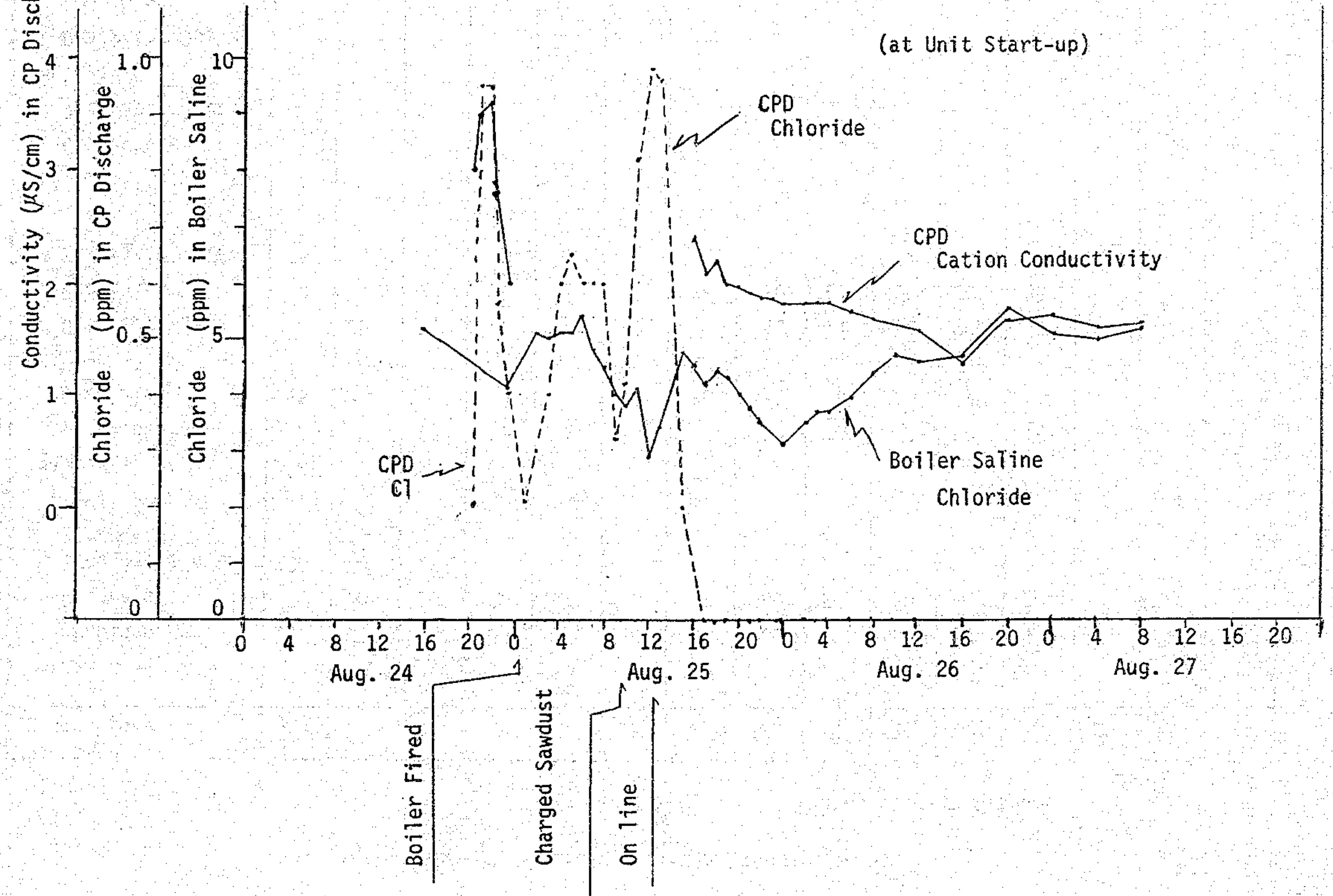


Table 5C-16 DISSOLVED OXYGEN ANALYSIS AT GSTP AND MALAYA

(Indigo Carmine Method)

(ppb)

Month/day	8/9	10	11	12	13	16	17	18	19	20	21	22	26	27			
Gardner -1																	
CP Discharge	100	70	15	50		50	55	60	70	80	80	30					
Feedwater	70	30	10	55		30		50	50	20	40	30					
Condensate after heater	80	10	15														
Snyder -1																	
CP Discharge		25	20	20	4	6		30	30	40	30	15					
Eco Inlet	15	20					20	15	15	20	8	4					
Snyder -2																	
CP Discharge		35	25	60		50		40	40	50	20	50					
Eco Inlet				15			20	10	10	10	20	20					
Deaerator Inlet	0	0		0	0	0				4	4	2					
				15													
Malaya -1																	
Condensate													0	0			
Deaerator Outlet														0			
Malaya -2																	
Deaerator Outlet													0				
Eco Inlet													0				

Fig. 5C-8 CHLORIDE AND SILICA OF BOILER SALINE AT GARDNER-1 (August 1-24)

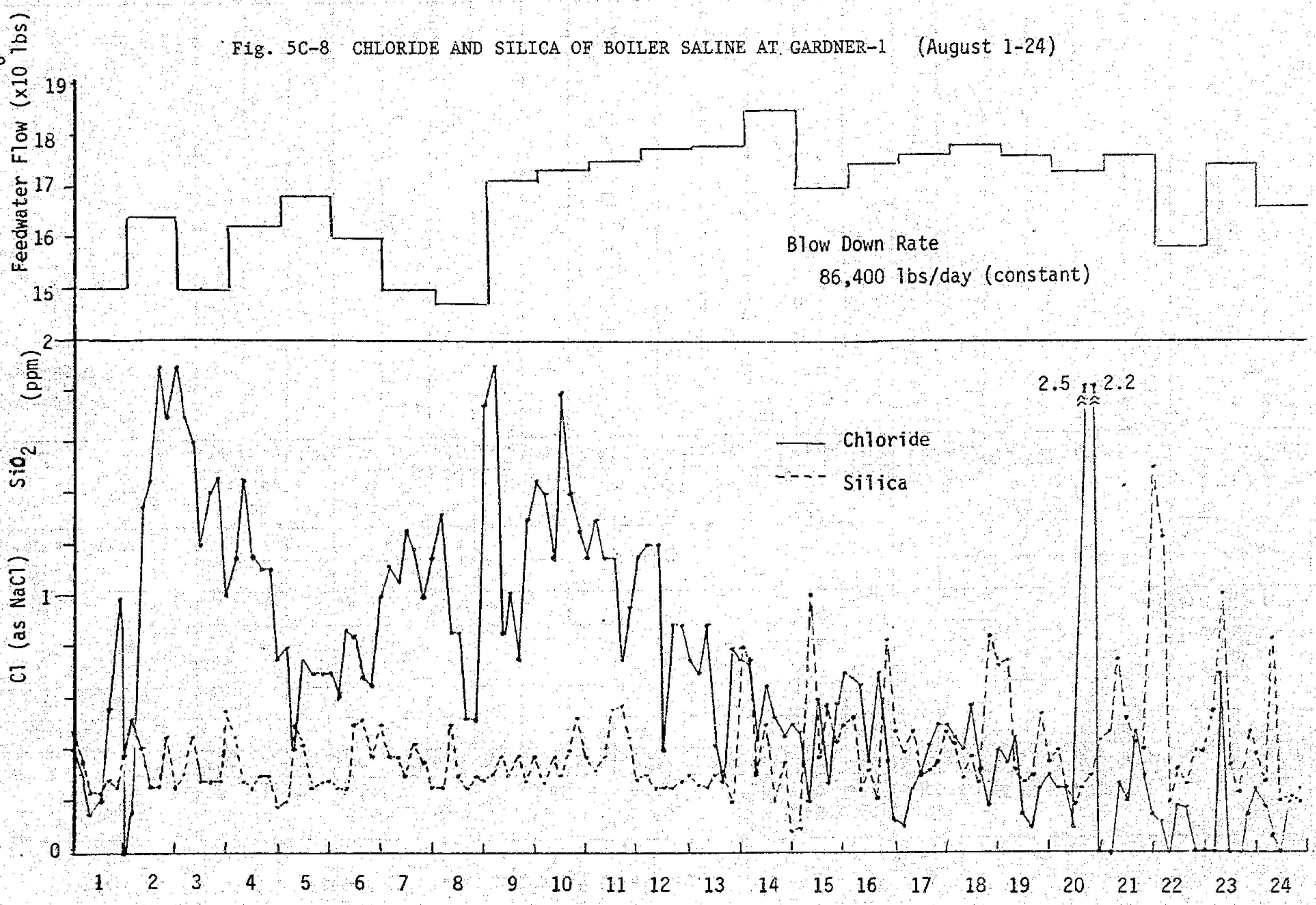


Table 5C-17 MONTHLY REPORT ON WATER ANALYSES (Example)

Item / Sample	pH (at 25°C)			Conductivity ($\mu S/cm$)			Fe (ppm)			SiO_2 (ppm)			M-Alkalinity (ppm as $CaCO_3$)			Sulfate (ppm as SO_4)			Chloride (ppm as Cl)			Total Hardness ppm as $CaCO_3$		
	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN
Raw Water																								
Filtered Water																								

Item / Sample	Conductivity ($\mu S/cm$)			SiO_2 (ppb)					
	AVG	MAX	MIN	AVG	MAX	MIN			
Demineralizer									

Item / Sample	pH (at 25°C)			Turbidity (ppm)			N_2H_4 (ppm as N_2H_4)		
				AVG	MAX	MIN	AVG	MAX	MIN
HSCC									

Item / Sample	pH (at 25°)			Cation Cond ($\mu S/cm$)			Fe (ppb)			Cu (ppb)			SiO_2 (ppb)			DO_2 (ppb)			N_2H_4 (ppb)			Cl (ppb)		
	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN
Condensate																								
Feedwater																								
—																								
—																								
—																								
—																								
—																								

Reference - 5 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 molar 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

Dardness 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 micro S/cm equal or less	0.3 micro S/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 micro S/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
Cation Conductivity (25°C)	less than 0.3 micro S/cm

Boiler Water

Hydrogen Ion Valve (pH) ------------- Between 9.5 and 10

Total Solids ------------------------- Less than 20 ppm

Phosphoric Acid (POa_3) -------------- Between 1 and 3 ppm

Silica (SiO_2) ----------------------- Preferably less than 0.3 ppm

3) Management

a. Result of Survey

Daily laboratory analysis and performance reports about chemical equipment such as demineralizer, ammonex are checked by the chief of shift and submitted to the superintendent. However, it is observed that copies of these reports are not submitted to the Plant Manager, except only in cases of abnormal phenomena. Statistical analysis of the water analyses data, the arrangement and resolution about the water quality log or special test, etc., is scarcely performed which is mainly due to man-power deficiency. Monthly and yearly reports about water quality analysis and chemical consumption are not also submitted. It is also observed that chemistry control is not religiously maintained because of too much paper work being done.

b. Recommendation

As the technique pertaining thermal power generating unit advances quickly, chemical management becomes very important. This is also true to geothermal power plants which are already operational and to the nuclear power plant that would soon follow.

Therefore, a central laboratory should be established as the managing organization about chemical works of the power station, in order to do planning and make recommendation for the improvement of chemical techniques and training.

For an effective planning, an initial manpower of 5 to 7 staff members which will take charge of the enumerated tasks below should be established:

- Collection and review of water quality at each unit
- Monthly and yearly reports
- Chemical inspection and material testing during annual outage
- Advices on chemical control pertaining to unit outage
- Presence of trained personnel during chemical cleaning
- Solution of common problems of the chemical section
- Training, observation or education
- Introduction of new technique about chemical treatment (literature, equipment and analysis method)
- Thorough examination of equipment related to chemistry

In the near future, once the central laboratory is operational, an overall manpower of around 20 members should be utilized under the said laboratory to cope with problems which would arise in thermal, geothermal and nuclear power plants. The task includes special water analysis, material corrosion control and analysis, fuel and environmental pollution.

Required instruments for future central laboratory are as follows:

- Electron probe X-ray micro analyzer
- Inductively coupled argon plasma emission spectrophotometer (multi-channel type)
- Ge (Int*) gamma-ray spectrometer
- Scanning electron microscope
- Fluorescent X-ray analyzer
- X-ray diffractometer
- Atomic absorption spectrophotometer
- Gas chromatography
- Carbon-nitrogen-hydrogen analyzer
- Total nitrogen analyzer
- Ion chromatography (dionex)
- Sulfur analyzer
- Metal microscope

*Int: Intrinsic (or pure)

The above instruments/equipment are installed at Kyushu Electric Power Research Laboratory.

4) Demineralizer

a. Specification of Demineralizer

(a) Raw Water Quality of Demineralizer

Item	Raw Water	Treated Water
Ca^{++}	22 ppm as CaCO3	
Mg^{++}	22 "	
Na^{++}	376 "	
Total Cation	420 "	0.1 ppm as CaCO3
$HCO3^{-}$	307 ppm as CaCO3	
Cl^{-}	107 "	
$SO4^{--}$	6 "	
$NO3^{-}$	0 "	
CO2	0 "	
SiO2	86 "	0.01 ppm as SiO2
Total Anion	506 "	0.1 ppm as CaCO3
Fe	0.125 ppm as Fe	0.01 ppm as Fe
pH	8.3	7.0

(b) Raw Water Quality of RO Unit (Tested by ESCO)

Ca^{++}	50 ppm	$HCO3^{-}$	383 ppm
Mg^{++}	25 ppm	Cl^{-}	342 ppm
Na^{+}	320 ppm	$SO4^{--}$	14 ppm
Total Cation		$NO3^{-}$	0.6 ppm
pH	7.8	SiO2	65 ppm
Fe	0.24 ppm	Total Anion	
Turb.	Nil		
TDS	1198 ppm		

NOTE: Result of raw water quality test submitted by ESCO is inadequate so that total cation and anion cannot be evaluated.

(c) Designated Values

Location	Gardner	Snyder	Malaya
Manufacturer	Graver	Permutit	Permutit
Cation Exchanger			
Number	3 Units	2 Units	2 Units
Column Size	54" x 13'-6"	72" x 11'	
	(1-372mm$^{\phi}$x4115mm^{H})	(1829mm$^{\phi}$x3353mm^{H})	same
Pressure	100 psi	100 psi	
	(7kg/cm^2)	(7kg/cm^2)	same
Resin	Re-3 108ft^3	IR-120 172ft^3	same
Regenerant			
Up-Flow	66°Be H_2SO_4(8lbs/ft^3)	93% H_2SO_4(7lbs/ft^3)	same
Down-Flow	66°Be H_2SO_4(10lbs/ft^3)	93% H_2SO_4(112g/L-R)	same
Flow Rate	50 gpm	100 gpm	same
	(11.4 m^3/H)	(22.7 m^3/H)	same
B.T. Capacity	24.2 Kgrain/ft^3	19.6 Kgrain/ft^3	same
	(55.3 g/l-R)	(44.8 g/l-R)	
Total Capacity	90500 gal	136400 gal	same
	(286 m^3)	(516.3 m^3)	same
Degasifier			
Number	1 Unit	1 Unit	1 Unit
			same

<u>Anion Exchanger</u>

Number	3 Units	3 Units	3 Units
			same
Column Size	48" x 15'-6	60" x 9'	
	(1219mm$^{\phi}$x4724mm^{H})	(1524mm$^{\phi}$x2743mm^{H})	same
Pressure	100 psi	100 psi	same
	(7 kg/cm^2)	(7 kg/cm^2)	same
Resin	AE-61 96 ft^3	IRA-402 102 ft^3	same
	(2718 lit)	(2888 lit)	same
Regenerant	100% NaOH 10lb/ft^3	100% NaOH 6lb/ft^3	same
Flow Rate	50 gpm	100 gpm	same
	(11.4 m^3/H)	(22.7 m^3/H)	same
B.T. Capacity	10.7 Kgrain/ft^3	13.8 Kgrain/ft^3	same
	(24.4 g/l-RO)	(31.5 g/l-R)	same
Total Capacity	71000 gal	125600 gal	same
	(269 m^3)	(475.4 m^3)	same

<u>Mixed Bed Polisher</u>

Number	2 Units	2 Units	2 Units
Column Size	36" x 8'	42" x 9'	same
	(914mm$^{\phi}$x2438mm^{H})	(1067mm$^{\phi}$x2743mm^{H})	same
Pressure	275 psi		
	(19.3 kg/cm^2)		
Resin	Anion (AE-61)	Anion (IRA-402)	same
	11 ft^3	24 ft^3	same
	(311 lit)	(679 lit)	same
	Cation (RE-6)	Cation (IR-120)	same
	17 ft^3	28 ft^3	same
	(481 lit)	(792.8 lit)	same

Flow Rate	76 gpm	100 gpm	same
	(17.3 m^3/H)	(22.7 m^3/H)	same
Total Capacity	1000000 gal	514000 gal	same
	(3785 m^3)	(1946 m^3)	same
Regenerant	100% NaOH 24 lb/ft^3	100% NaOH 9 lb/ft^3	same
	(384 g/l-R)	(144.2 g/l-R)	same
	66'Be H_2SO_4 8 lb/ft^3	(93% H_2SO_4 same 8 lb/ft^3)	

Effluent	Total Cation	0.1 ppm as $CaCO_3$
	Total Anion	0.1
	SiO_2	0.01 ppm as SiO_2
	Fe	0.01 ppm as Fe
	pH	7.0
	Conductivity	0.5 micro S/cm

Note: At Gardner/Snyder Thermal Station, Graver type Demineralizer treats directly filtered water with a conductivity of 820 micro S/cm and permutit Type of Demineralizer treats blended water with a conductivity of 390 micro S/cm. Blended water comes from RO unit effluent with a conductivity of 170 micro S/cm and deepwell water with a conductivity of 1300 micro S/cm.

b. Result of Survey

(a) Instrumentation of Demineralizers

The instrumentation which are mounted on the control panel of demineralizer are as follows;

i. <u>Gardner Demineralizer (Graver)</u>

Instruments for Monitoring	
Conductivity Meter & Recorder (Leeds & Northrup)	X
pH Meter & Recorder (Leeds & Northrup)	X
Flow Meter & Recorder (Foxboro)	X
Control System for Automatic Operation	
Stepping Programmer	X
Alarm Unit	
Alarm Units	X

ii. <u>Snyder Demineralizer (Permutit)</u>

Instruments for Monitoring	
Conductivity Meter & Recorder (Beckman)	X
Flow Meter & Recorder (Taylor)	
Flow Counter	X
Control System for Automatic Operation	
Stepping Programmer	X
Alarm Unit	
Alarm Units	X

iii. <u>Malaya Demineralizer (Permutit)</u>

Instruments for Monitoring	
Conductivity Meter & Recorder (Beckman)	X
Flow Meter & Recorder (Foxboro)	
Flow Counter	X
Control System for Automatic Operation	
Stepping Programmer	X
Alarm Unit	
Alarm Units	X

*Legend X - - - - - Out of Order

- - - - - Working but necessary to calibrate

O - - - - - Available

As mentioned above, the monitoring instruments and control system for automatic operation are mostly damaged and all equipments are operated manually. Faulty operations may occur as a result.

(b) Treated Water Quality

The filtered water and outlet of demineralizer are as follows;

Date	Filtered Water Conducti. (µS/cm)	Cation FMA (ppm as $CaCO_3$)	Anion Conduct. (µS/cm)	Anion SiO2 (ppm)	Mixed Bed Polisher Conduct. (µS/cm)	Mixed Bed Polisher P-Alkali (ppm as $CaCO_3$)	Mixed Bed Polisher SiO2 (ppm)	Remarks
Aug. 10	850	190	4.7 4.9	0.004	0.55 0.94		0.005	Graver (Gardner)
12		180	17	0.004	1.0		0.005	
13	810	180	7.8 6.0	0.004	0.15		0.005	
13			3.1 2.3	0.004	0.12		0.005	
16	810	180	34 8.3	0.004	0.78		0.005	
17	810	180	10 6.5	0.004	0.32		0.005	
18	830	185	12 10	0.004	0.30		0.005	
	Deep Well							
Aug. 16	1300 *390	RO unit 70	effluent 5.4	170 S/cm -	0.11		-	Permutit (Snyder)
	* Blended Water in Clear Well							
Aug. 24	480		5.5		0.17			Permutit (Malaya)
24			3.4		0.18			
25	450		11		0.27			
26	450		2.8		0.23			
27	480		2.5		0.25			
Sep. 1	568		2		0.22			

FMA & SiO2 --- By NAPOCOR

In Japan, the demineralizer is usually operated as follows;

Anion Exchanger Outlet

Conductivity	Less than 10 micro S/cm
Silica	Less than 0.1 ppm as SiO_2

Mixed Bed Polisher

Conductivity	Less than 0.5 micro S/cm
Silica	Less than 0.02 ppm as SiO_2

However, treated water conductivity of Graver demineralizer becomes sometimes higher than the above values.

It is caused by no monitoring of conductivity at anion exchanger and mixed bed polisher outlet, Exhausted points are checked only by Free Mineral Acidity (FMA) (Cation exchanger), SiO_2 (Anion exchanger), SiO_2 and P-alkalinity (Mixed bed polisher) by manual analysis.

(c) Regeneration

Regeneration of demineralizers are carried out as follows:

	Cation Exchanger	Anion Exchanger	Mixed Bed Polisher
Gardner (Graver)	(1) Down Flow	(4) Down Flow	(7)
	(2) Up Flow	(5) Down Flow	(8)
	(3) Down Flow	(6) Down Flow	Ordinary
Snyder (Permutit)	(1) Down Flow	(1) Down Flow	Method
	(2) Down Flow	(2) Down Flow	(2)
Malaya (Permutit)	(1) Down Flow	(1) Down Flow	(1) Column (No)
	(2) Down Flow	(2) Down Flow	

* Refer to attached operation process; Table 5C-21, 22, 23, 24, 25 and 26.

(d) Regenerants Quantity

Regenerants quantity is checked by dilution flow rate and specific gravity of diluted solution.

Table 5C-19 FILTERED WATER ANALYSIS RECORD

BY

Items		M-Alk. (ppm as CaCO3)	Cl (ppm as NaCl)	SO4 (ppm as Na2SO4)	T-Hard (ppm as CaCO3)	Ca (ppm as CaCO3)	SiO2 (ppm as SiO2)	Conduct (Micro S /cm)	FMA (ppm as CaCO3)	
Aug.	1	223	185	9	35	18	66	979	180	G/S TS
	2	285	183	16	30	20	68	894	180	
	3	340	184	14	40	24	70	970	180	
	4	310	170	20	46	20	90	990	180	
	5	280	174	12	42	26	65	940	180	
	6	290	160	9	48	25	83	990	180	
	7	308	185	12	38	24	68	968	180	
	8	320	192	12	44	20	72	980	180	
	9	300	176	12	40	24	84	974	180	
	10	290	184	10	40	16	54	940	190	
	11	340	184	12	46	20	65	970	180	
	12	320	190	12	46	20	78	-	180	
	13	309	188	14	40	28	72	972	180	
	14	370	190	10	44	20	60	980	180	
	15	260	162	10	34	17	55	900	180	
	16	290	170	15	38	20	72	(820)	180	
	17	270	182	10	42	24	62	(840)	185	
	18	-	-	-	-	-	-	-	-	
	19	300	116	12	34	20	42	(800)	190	
	19						#4	(1300)----RO Unit Inlet (170)----RO Unit Outlet		
	19							(390)----Permutit Inlet		
Aug.	27 #1	138	44	21.9	102	66	80	PH(7.3)	Fe(0.41)	MALAYA
	#2	136	46	21.9	102	58	82.5	PH(7.65)	Fe(0.41)	
	#3	56	24	17.5	64	54	97.5	PH(7.45)	Fe(0.46)	
Aug.	City	48 - 43	13 - 15		41 - 46	28 - 32	10.8 - 16	PH(7.3)		TEGEN
	River	82 - 76	620 - 580		120 - 118	75 - 80	6.7 - 6.0	PH(7.5)		

Table 5C-20 FILTERED WATER ANALYSIS RECORD

Item / Date		M-Alkali (ppm as Ca CO3)	Cl (ppm as NaCl)	SO4 (ppm as Na2SO4)	H-Hard (ppm as CaCO3)	Ca (ppm as CaCO3)	SiO2 (ppm as SiO2)	Conduct (Micro S /cm)	FMA (ppm as CaCO3)	Remarks
Aug.	1	20	70		12	4			60	Snyder
	2	15	70		0	0			40	
	3	5	60						40	
	4									
	5	30	70		14	4			50	
	6	22	66		0	0			50	
	7	26	68		0	0			40	
	8	15	40		0	0			40	
	9	9	88		0	0			40	
	10	10	90		0	0			40	
	11	58	85		20	12			40	
	12	64	90		22	10			40	
	13	72	100		24	14			70	
	14	68	94		20	8			80	
	15	74	104		22	12			70	
	16	70	94		22	10	15		70	
	17	68	108		20	12	15	390	70	
	18	72	104		22	14				
	19	70	120		28	14	20		70	
	20	90	110		20	12	18		70	
	22	60	94		18	10			80	
	23	64	102		22	12			80	
	24	60	82		16	8			80	
	-									
	31	17	70						40	
			Sep. 17							
		Note;	#4 Deep Well Water Conductivity 1300 Micro S/cm							
			RO Unit Treated Water Conductivity 170 Micro S/cm							
			Permutit Inlet Water(Blended Water) Conductivity 390 Micro S/cm							

Table 5C-21 OPERATION PROCESS OF PRIMARY DEMINERALIZER (GRAVER) GSTP

Cation Exchanger

Process	Flow Rate	Time	Remarks		
Service	50 gpm				
Back Wash	150 gpm	10 min.			
Clouse	-	5 min.			
	Method-1(Up Flow)		Method-2(Down Flow)		
1-st Introduction	2.5%Acid 45 gpm + 0.7 gpmH2SO4	31 min	4%Acid 39.2 gpm + 1.0 gpmH2SO4	29 min	
2-nd Introduction	5%Acid 45 gpm + 1.4 gpmH2SO4	22.5 min	8%Acid 39.2 gpm + 2.0 gpmH2SO4	21 min.	
Displacement	45 gpm	10 min	39.2 gpm	125 min.	1.3 m^3
Fast Rinse	92 gpm	47 min			16.3 m^3
Service	73 gpm				
Remarks					

Anion Exchanger

Process	Flow Rate	Time	Remarks	
Service	50 gpm			
Back Wash	42 gpm	10 min.		
Clouse				
Clouse				
Caustic Introduction	29.7 gpm + 1.75 gpm(NaOH) Heating 110-120'F	87 min		
Displacement	29.7 gpm Heating 110-120'F	23.5 min		2.6 m^3
Fast Rinse	73 gpm	54.5 min		15 m^3
Remarks				

Table 5C-22 MIXED BED POLISHER (GRAVER) GARDNER

Operation Process, Specified Flow Rate, Time, Regenerants

Process	Flow Rate	Time	Remarks	
Service	75 gpm			
Sub-Service Wash	21 gpm	10 min.		
Back Wash	25 gpm	10 min.		
Settling	-			
Acid Introduction Acid Displace & Caustic Intro	11.4 gpm +0.355 gpm(H_2SO_4) 5.3 gpm +0.30 gpm(NaOH) 11.4 gpm	25 min.	Heating Temp 110-120'F	
Acid Displace Caustic Intro-duction	11.4 gpm 5.3 gpm +0.3 gpm(NaOH)	69 min.		
Drain Unit	-	11.4 min.		
Raise Bed	25 gpm			
Air & Water				
Air Mixing				
Back Flush & Settle & Air				
Slow Fill	5.3 gpm	8 min.		
Fast Fill	41 gpm	3.5 min.		
Through Fill	41 gpm			

Table 5C-23 OPERATION PROCESS OF DEMINERALIZER (PERMUTIT) SNYDER

Cation Exchanger					Anion Exchanger				
Process	Flow Rate (gpm)	Time (min)	Remark		Process	Flow Rate (gpm)	Time (min)	Remark	
Service	100				Service	100			
					Back Wash	40	20		
Back Wash	140	10							
Settle		5			4% Caustic Introduction	28 + 1.6	60	Heating Temp 120°F	
1.5% Acid Introduction	250 + 2.15(H_2SO_4)	11							
4% Acid Introduction	90 + 2.15(H_2SO_4)	11							
6% Acid Introduction	60 + 2.15(H_2SO_4)	16							
Slow Rinse	60	14		3.1 m^3					
Fast Rinse	250	24		22.7 m^3	Slow Rinse	28	22		2.3 m^3
					Fast Rinse	120	68	Less than 40 Micro S/cm	30.8 m^3

Table 5C-24 SNYDER THERMAL STATION
OPERATION PROCESS OF PRIMARY
DEMINERALIZER (PERMUTIT)

Process	Flow Rate(gpm)	Time(min)	Remarks
Service	100		
Back Wash	33	10	
Settle	——	10	
Heating Anion Resin	10 8.5	15	Heating Temp 120'F
Caustic Introduction & Acid Introduction	10 + 0.6 8.5 + 0.25	60	Heating Temp 120'F
Slow Rinse	10 8.5	15	
Anion Partial Rinse Cation Partial Rinse	48 55	15	
Drain	——	15	
Air Mix	150 cfm	20	Air Press 10 psi
Air Mix & Drain	150 cfm	10	
Refill	80	5	
Final Rinse	80	13	
Conductivity Setting			0.5 Micro S/cm

Table 5C-25 MALAYA THERMAL STATION

OPERATION PROCESS OF PRIMARY DEMINERALIZER (PERMUTIT)

Cation Exchanger

Process	Flow Rate	Time	Remarks	
Service	100 gpm ([illegible] gpm)Max.			
Back Wash	115 gpm	20 min.		
Settle				
1-st (1% Acid) Introduction	217 gpm + H_2SO_4 (1%)SG 1.015	20 min.		
2-nd (4% Acid) Introduction	79 gpm + H_2SO_4 (4%)SG 1.025	20 min.		
3-rd (6% Acid) Introduction	52 gpm + H_2SO_4 (6%)SG 1.04	20 min.		
Slow Rinse	52 gpm	22 min.		4.3 m^3
Rinse	222 gpm		End point 40 FMA 45	42 m^3
Service	102 gpm			

Anion Exchanger

Process	Flow Rate	Time	Remarks	
Service	100 gpm (200 gpm) Max.			
Back Wash	69 gpm	30 min.		
Settle				
Settle				
Caustic(4%NaOH) Introduction	17 gpm + NaOH (4%)SG 1.04 Heating Temp. 110-120'F	60 min.		
Slow Rinse	17 gpm	30 min.		19 m^3
Rinse	102 gpm		End Point P-Alkali Less than 10 ppm SiO_2 Less than 0.02ppm	23 m^3

Table 5C-26 MIXED BED POLISHER (PERMUTIT)
(SNYDER & MALAYA)

Operation Process, Specified Flow Rate, Time and Regenerants

Process	Flow Rate	Time	Remarks	
Service	100 gpm			
Back Wash	43 gpm	10min.		
Settling	-	5min.		
Anion Heating	9.7 gpm (Temp.110-120'F)	15min.	Heating Temp 110-120'F	
Regenerant Introduction	Anion (5%NaOH)S.G.1.05 9.7 gpm + NaOH Cation (5%H2SO4) S.G.1.05 7.1 gpm + H2SO4	60min.	Heating Temp 110-120'F	
Displacement	Anion 9.7 gpm Cation 7.1 gpm	15min.	Heating Temp 110-120'F	
Regenerant Rinse	Anion 39 gpm Cation 50 gpm	15 min.		
Final Rinse	69 gpm		Conductivity Less than 0.5 Micro Silica Less than 0.02 ppm	

Fig. 5C-9 DEMINERALIZERS SCHEMATIC DIAGRAM

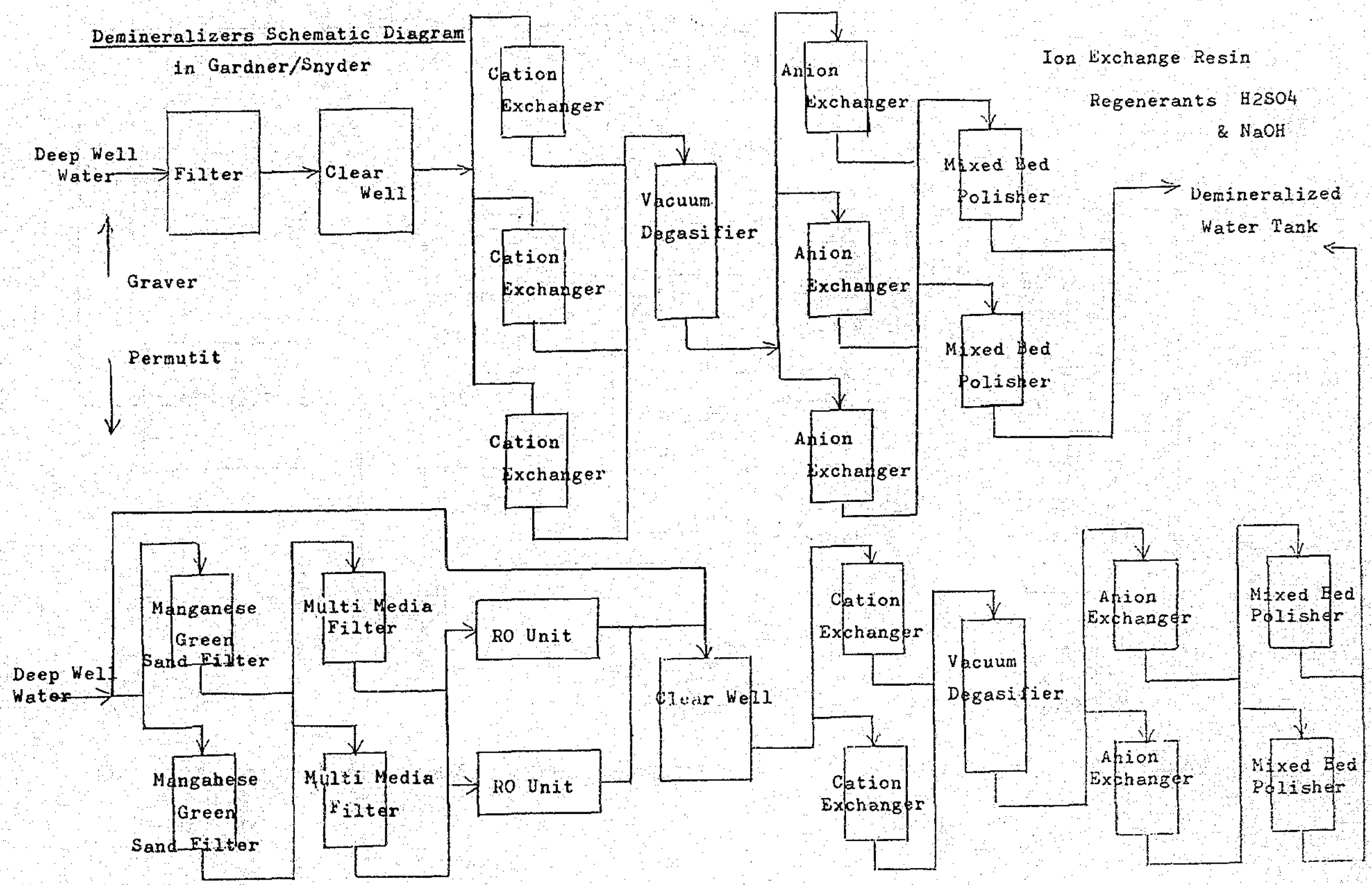


Fig. 5C-10 DEMINERALIZERS SCHEMATIC DIAGRAM (PERMUTIT)

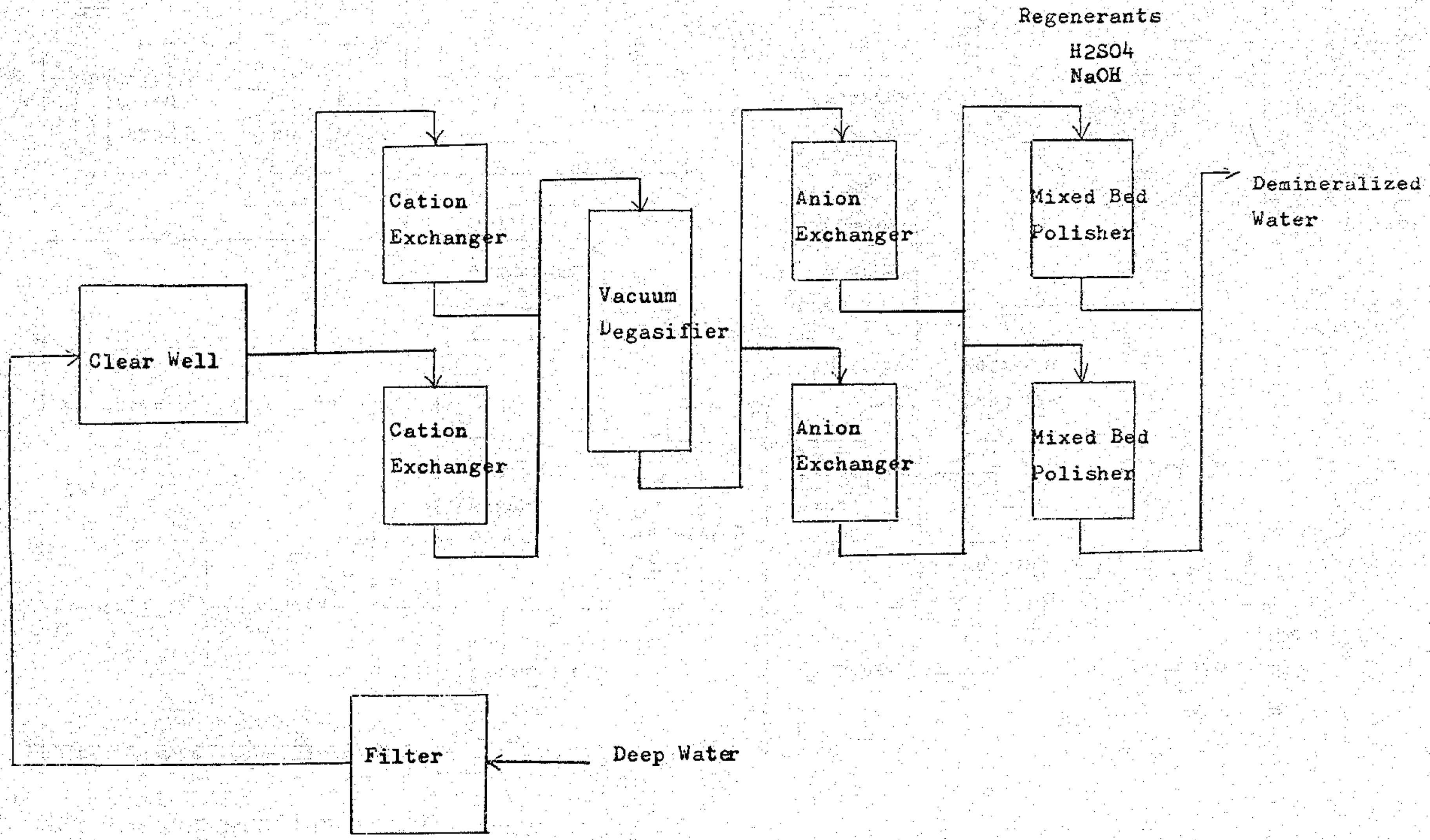
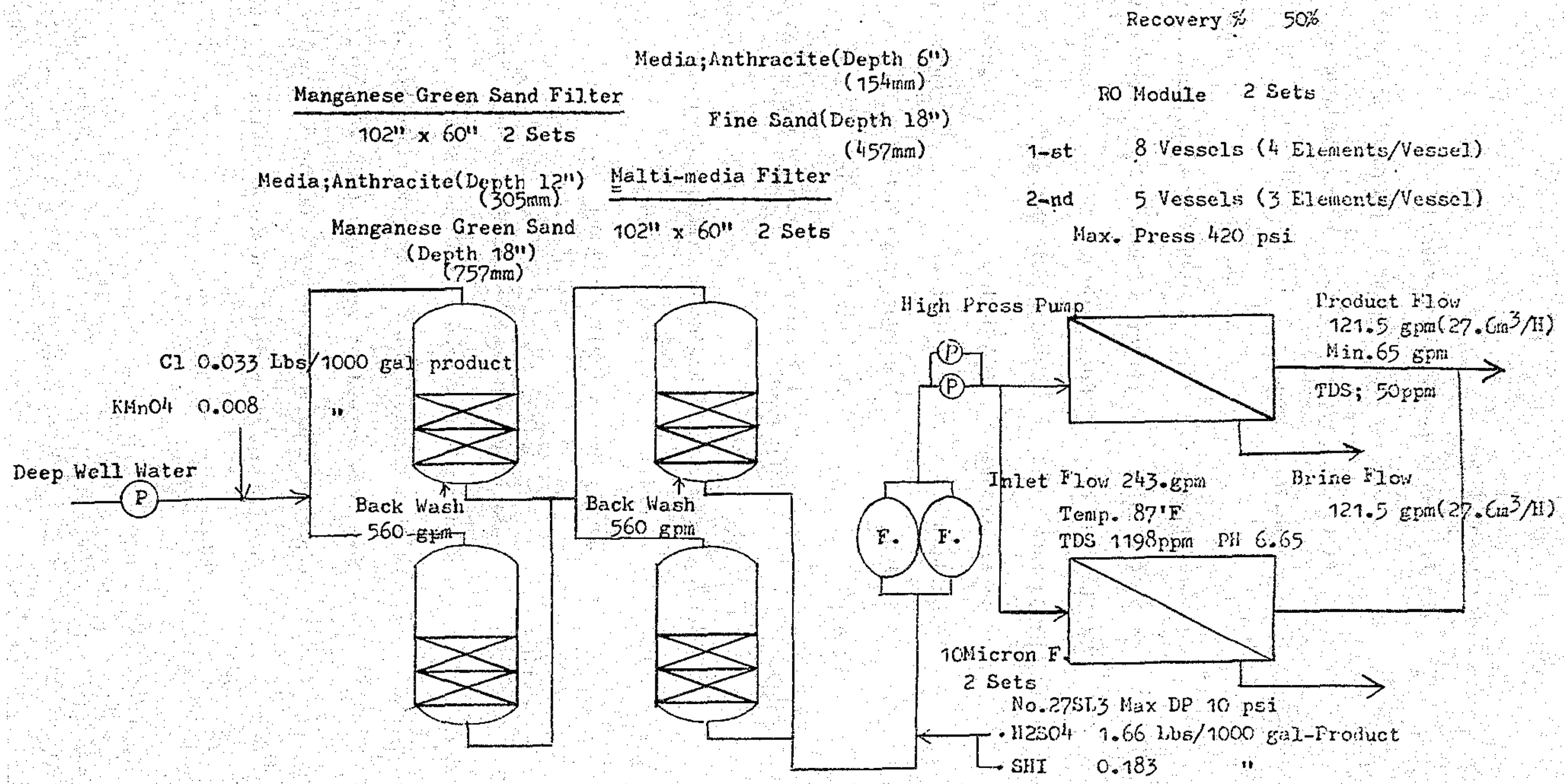


Fig. 5C-11 REVERSE OSMOSIS (RO) UNIT

Manufacturer; Envirogenics System Co.,

Location; Snyder Thermal Station



c. Recommendations

(a) Filtered Water Analysis Method

According to NAPOCOR thermal station site, filtered water (raw water) is analyzed based on the following methods.

	Method	Unit
* P-Alkalinity	Titrate with N/50 H_2SO_4	ppm as $CaCO_3$
* M-Alkalinity	Titrate with N/50 H_2SO_4	ppm as $CaCO_3$
* Chloride	Morr Method	ppm as NaCl
* Sulfate	Turbidimetric Method	ppm as Na_2SO_4
* Total Hardness	EDTA Method	ppm as $CaCO_3$
* Ca Hardness	EDTA Method	ppm as $CaCO_3$
* Silica	Molybdate Blue Method	ppm as SiO_2
* pH	pH Meter	
* Free Mineral Acidity	Titrate with N/50 NaOH	PPM as $CaCO_3$

Note: Refer to attached sheets (Filtered water analysis record.)

No. - - - - - Table 5C-19 and 20.

In above method of analysis items, chloride and sulfate are expressed as NaCl and Na_2SO_4 respectively on this record. This is not suitable because it is thru this record of analysis that we calculate the expected capacity of primary demineralizers by knowing the total cation and total anion of the raw water.

This is to say, the primary demineralizers capacity can be known by the following formula.

* Expected capacity of primary demineralizer*

$$A = \frac{B \times C}{D} \times E - F$$

A ;	Expected capacity of demineralizer	(m^3/cycle)
B ;	Break through capacity of resins	(g as $CaCO_3$/l-Resin)
C ;	Resin Volume	(liter)
D ;	Total cation/Total anion	(ppm as $CaCO_3$)
E ;	Resin capacity drop %	(1 - %/100)
F ;	Needed water volume for regeneration (Displacement & Rinse)	(m^3)

The analysis items and methods of filtered water in Japan are shown below;

	Method-1 (JIS-0101)	Method-2	Method-3
Total Hardness(T-H)	Titration with EDTA	Titration with EDTA	
Calcium (Ca)	Titration with EDTA		
Magnesium (Mg)	(T-H) - Ca		
Sodium (Na)	Atomic Absorption	(T-C) - (T-H)	
Total Cation (T-C)	Ca + Mg + Na	M-Alkali + FMA	Conductivity/2
Bicarbonate (HCO3) (M-alkalinity)	Titration with N/50 H_2SO_4	Titration with N/50 H_2SO_4	
Chloride (Cl)	Morr Method	Free Mineral Acidity (FMA) Titration with N/50 NaOH	
Sulfate (SO_4)	Turbidimetric Method		
Nitrate (NO_3)			

Free carbon Dioxide (CO_2)	From graph of relation of pH	and M-alkalinity
Silica (SiO_2)	Molybdate Yellow	Molybdate Yellow
Total Anion	HCO_3 + Cl + SO_4 NO_3 + CO_2 + SiO_2	M-Alkali + FMA CO_2 + SiO_2
pH	pH meter	pH
Iron (Fe)	Orth-phenanthroline	-
Conductivity (Micro S/cm)	Conductivity	Conductivity meter
Turbidity	Spectrophotometer	
Others		
COD	Titration ($KMnO_5$)	
TOC	TOC meter	
Frequency of analysis	once a week	once a day -

Regarding raw water analysis, JICA team recommends that it should be performed periodically as follows:

Filtered Water (Method-1) Once a week

Filtered Water (Method-2) Once a day

SiO_2 of Anion and Mixed Bed Polisher Outlet Every 3 hours

In the filtered or raw water supply analysis, expression of results should be unified as $CaCO_3$ or its equivalent for easy calculation.

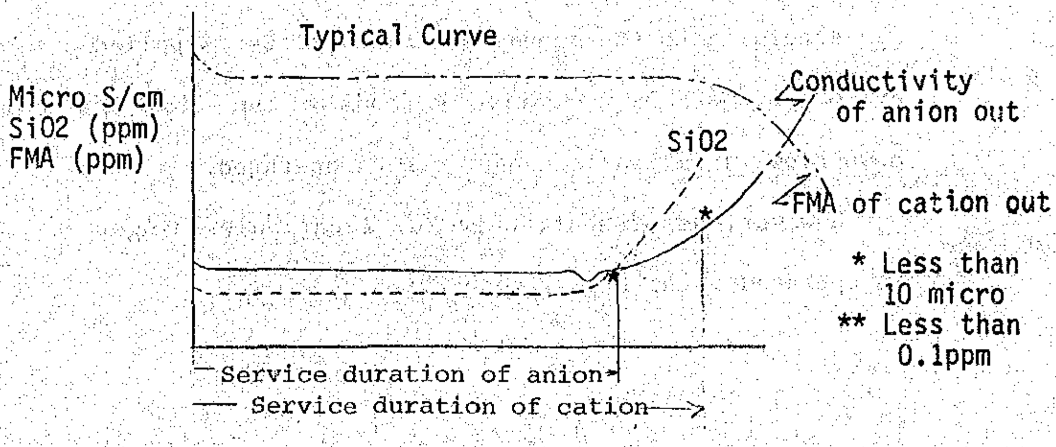
Note: On the attached record of analysis (Table 5C-20), chloride values are higher than FMA (Free Mineral Acidity). Further evaluation of this results shows the probable cause of the big difference in value may be due to the reagent concentrations.

(b) Operation Procedure of Demineralizer

According to NAPOCOR procedure, the exhausting points of cation exchanger and anion exchanger are respectively decided with free mineral acidity and silica value but not on the conductivity value.

However, the conductivity of deionized water is the most important factor when we check the demineralized water quality.

In primary demineralizer, the typical curves of conductivity, SiO_2 and FMA (Free Mineral Acidity) are shown below.



And when NaOH or NaCl leak at outlet of ion exchanger, the conductivity will be as follows;

$CaCO_3$	NaOH	NaCl	HCl
1 ppm	5 micro S/cm	2.5 micro S/cm	8.5 micro S/cm
5 ppm	25 "	13 "	43 "
10 ppm	50 "	25 "	85 "
15 ppm	75 "	38 "	150 "
20 ppm	100 "	40 "	170 "

FMA at the outlet of cation exchanger correspond to NaCl. Conductivity measure is higher in sensitivity than the result of FMA analysis. Monitor continuously by conductivity.

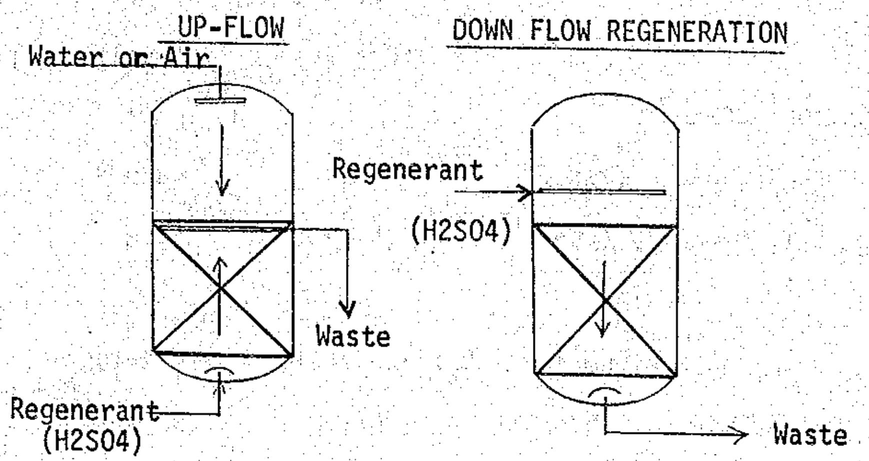
Therefore, JICA team recommends, that the exhausting points of demineralizer should be known by conductivity and conductivity meters which are attached on the control panel should be repaired or replaced immediately. Regarding mixed bed polisher, it is also the same as mentioned above.

(c) Regeneration Method

According to the manual of demineralizer supplied by Graver both regeneration methods of up flow or down flow in cation exchanger can be operated.

However, at present, only No. 2 cation exchanger is operated in up flow regeneration.

When concentration of free mineral acidity (Cl^-, SO_4^-, No_3^-, etc.) in filtered water increase, it is better to employ up flow regeneration in order to keep higher water quality efficient. Also higher capacity will be produced with smaller volume of regenerants.



Therefore, JICA team recommends that up-flow regeneration method should be employed in Gardner (Graver) demineralizer to obtain higher quality of water effluent.

In up-flow regeneration, the most important thing is to avoid resin moving during acid introduction and also of displacement so that water or air is flowed from column top. Regeneration waste collector is installed in upper part of resin layer.

(d) Caustic Introduction & Displacement Temperature

The maximum operating temperature of anion exchange resin in R-OH type is 60°C. "In case of NAPOCOR, it is between 110°F (43°C) - 120°F (48°C)"

The heating temperature should be controlled at 53 ± 3°C in order to remove effectively SiO_2 absorped in resin layer.

(e) Expected Capacity of Demineralizer

In primary demineralizer, the expected capacity are as follows;

	Gardner (Graver)	Snyder (permutit)	Malaya (permutit)
CATION EXCHANGER			
Resin Volume (liter)	3058	4870	4870
B.T. Capacity (gas) ($CaCO_3$/1-R)	55.3	44.8	44.8
Total Cation(ppm as $CaCO_3$)	820/2=410	390/2=195	450/2=225
Resin Capacity Drop %	19/100	19/100	19/100
Regene. Water (m^3)	18	26	46
Expected Capacity (m^3/cycle)	316	880	739
ANION EXCHANGER			
Resin Volume (liter)	2718	2888	2888
B.T. Capacity (gas $CaCO_3$/1-R)	24.4	31.5	31.5
Total Anion(ppm as $CaCO_3$)	257	97	192
FMA (ppm as $CaCO_3$)	180	70	110
SiO_2 (ppm as CaO_3)	67	17	72
CO_2 (ppm as $CaCO_3$)	10	10	10
Resin Capacity Drop %	14/100	14/100	14/100
Regene. Water (m^3)	20	33	25
Expected Capacity (m^3/cycle)	204	774	382