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Burns and Roe Enterprises, Inc.

Kiev Combined Heat and Power Station #5
UKRAINE

FINAL

August 1997

Submitted by:	**Burns and Roe Enterprises, Inc.**
Submitted to:	**U.S. Agency for International Development**
Contract No.:	**CCN-0002-Q-00-3154-00** **Energy Efficiency and Market Reform Project** **Delivery Order No. 6, Task 1** **Increased Reliability, Improved Efficiency and Reduction of Environmental Impact**

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Delivery Order No. 6
Energy Efficiency and Reliability - Ukraine
Task 1 - Increased Reliability, Improved Efficiency and Reduction of Environmental Impact

Final Report
Kiev Combined Heat and Power Station #5

August 1997

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INCREASED RELIABILITY, IMPROVED EFFICIENCY AND
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I EXECUTIVE SUMMARY

A. INTRODUCTION

The Kiev Combined Heat and Power (CHP) Station #5 (Kiev-5) had various technical problems that, if unabated, could cause the heating system to fail and place the citizens of Kiev in jeopardy. Furthermore, unnecessary waste discharge into the Dnieper River posed an environmental risk.

The Burns and Roe project team visited Kiev-5 January 5-15, 1994, to assess the power station's technical problems. Of the many problem areas identified, USAID decided to expend funds on resin and filter materials, general hardware, and various plant instrumentation.

Delivery Order No. 6, Task 1, Increased Reliability, Improved Efficiency and Reduction of Environmental Impact at the Kiev Combined Heat and Power Station #5 was implemented. The results of this program are enclosed. The equipment was purchased by USAID and installed by Kiev-5 personnel.

B. RESULTS AND CONCLUSIONS (SUMMARY)

1. Results

- Increased water quality
- Increased water quantity
- Reduction in chemical reagent usage
- Reduction in waste water discharged into the Dnieper River
- Reduction in thermal pollution
- Reduction in greenhouse gases
- Increased safety to plant personnel
- Reduced steam turbine degradation
- Reduced plant expenditures
- Increased plant operational facility flexibility

2. Conclusions

USAID's program to increase reliability, improve efficiency, and reduce environmental impact at the Kiev Combined Heat and Power (CHP) Station #5 is a success. The assessment of quantiative and qualatitive improvements/benefits are both straight forward and deducible. Empirical data has been used and conservative assumptions have been made.

This program is a success due to the efforts and working relationships established between USAID, Kiev-5, Burns and Roe and its sub-contractors: Dow Chemical and Waters Equipment Company.

Similar projects, if instituted in other areas of Ukraine or other NIS countries should also achieve the improvements/benefits that Kiev-5 has obtained.

II DISCUSSION

A. MAKEUP WATER TREATMENT SYSTEM

The Makeup Water Treatment System takes raw water from the Dnieper River, clarifies and filters the water to be used in either the district heating water makeup system or the demineralized water system. See Appendix A.

The system is comprised of four (4) 310 ton/hr clarifiers receiving Dnieper River water for removal of hardness and suspended solids by the use of lime and ferrous sulfate. The settled sludge from the clarifiers' underflow is pumped to a settling pond 3 km from the power plant. Treated water from the clarifiers flows to four (4) 300 m^3 storage tanks.

The lime softened water is then filtered through seven mechanical filter tanks filled with crushed anthracite (coal) for removal of carryover of any excess lime and particulates. From the filters the water passes either to the demineralizer supplying water to the boilers or to seven (7) cation exchange resin sodium softeners for supplying water to the district heating system.

1. District Heating Water Makeup System

The District Heating Makeup System provides water to the District Heating Water System to replace system water losses which typically are 375 m^3/hr, but may often be as high as 450-500 m^3/hr.

The system is comprised of seven (7) cation exchange resin sodium softeners. Softened water flows from the softener to two (2) 300 m^3 storage tanks and then into the District Heating Water System.

The original inefficient, old type sulfonated coal cation exchange resin of Russian origin was replaced with Dow Chemical HCR-S/Na resin.

As a result of the addition of new resin the following improvements/benefits were achieved:

- water hardness was reduced 50%, from 570 μg equiv./kg to 288 μg equiv./kg.

- consumption of salt, used to regenerate the resin, was reduced 30% or more from 1200 tons/yr to 800 tons/yr.

- 50% reduction in system regeneration, therefore:
  - reducing manhours by 50%
  - reducing backwash water usage by 50%
  - reducing waste water discharge to the environment by 50%

2. Demineralized Water System

The Demineralized Water System consists of Boiler Makeup Water Demineralizer System, which receives clarified and filtered water from the Water Treatment System, and the Unit 3 and 4 Condensate Polishers (Unit Demineralizers).

a) Boiler Makeup Water Demineralizer

The Boiler Makeup Water Demineralizer system provides ultrapure makeup water to the boilers and is comprised of parallel trains of ion exchangers as follows:

four (4) First stage weak acid cation exchangers
four (4) Second stage strong acid cation exchangers
five (5) Weak base anion exchangers (2 - amberlite 112A-67)
two (2) Decarbonizers (degassifiers)
two (2) Storage tanks
four (4) Weak acid cation exchangers
five (5) Strong base anion exchangers
three (3) Strong acid/strong base mixed bed exchangers

The original inefficient, exhausted or missing ion exchange resins of Russian origin were replaced with Dow Chemical resins as follows:

	Item Number*	Russian	Dow Chemical
First Stage Cation	9	sulfonated coal	-
Second Stage Cation	10	SAC KY 2-8	HCR-S/H
First Stage Anion	11	WBA AN31	Marathon WBA
Third Stage Cation	15	sulfonated coal	HCR-S/H
Second Stage Anion	16	SBA AB17.8	SBR-P
Mixed Bed	17	SAC KY 2-8 SBA AB17.8	HCRW-2 SBR-P-C

* See Appendix A

As a result of the addition of the new resin the following improvements/benefits were achieved: (Appendix K)

- silica (SiO_2) was reduced 37% from 27 μg/kg to 17 μg/kg

- conductivity was reduced 18% from 0.1 → 0.12 μcm/sq. sm to 0.08-0.1 μcm/sq. sm

- throughput (amount of water treated before regeneration is required) increased as follows:

  - First Stage Cation increased 66% from 3,000 m^3 to 5,000 m^3
  - First Stage Anion increased 28% from 7,000 m^3 to 9,000 m^3
  - Second Stage Cation increased 300% from 5,000 m^3 to 20,000 m^3
  - Second Stage Anion increased 11% from 9,000 m^3 to 10,000 m^3
  - Mixed Bed increased 50% from 50,000 m^3 to 75,000 m^3

- consumption of acid for regeneration was reduced 5%

- consumption of caustic for regeneration was reduced 25%

- 37% reduction in regeneration therefore:

  - reducing manhours by 37%
  - reducing rinse water by 37%
  - reducing waste water discharge to the environment by 37%

b) <u>Unit 3 & 4 Condensate Polishers (Unit Demineralizers)</u>

Units 3 and 4 are supercritical units and as such require Condensate Polishers. The Condensate Polisher System is composed of eight (8) mechanical filters and seven (7) strong acid/strong base mixed bed exchangers.

The original mixed bed exchanger resin of Russian origin was replaced with Dow Chemical HCRW-2 and SBR-P-C resins.

As a result of the addition of new resin the following improvements/ benefits were achieved: (Appendix K)

- throughput (amount of water treated before regeneration is required) increased 60% from 250,000 m^3 to 400,000 m^3

- conductivity decreased 20% from 0.084 µcm/sq. sm to 0.067 µcm/sq. sm

- consumption of acid for regeneration was reduced 30%

- consumption of caustic for regeneration was reduced 30%

- 37% reduction in regeneration therefore:

  - reducing manhours by 37%
  - reducing rinse water by 37%
  - reducing waste water discharge to the environment by 37%

3. Plant Instrumentation

Necessary instrumentation throughout the plant either did not exist, or the existing instrumentation did not have the accuracy and responsiveness that is required to operate a power plant in today's economical and environmental setting. This lack of instrumentation required many parameters to be manually sampled and computed which lead to inaccuracies, slow response times and prevented the plant operating in its most economical mode. Therefore, various types of plant instrumentation have been installed, consisting of three (3) groups: sample panel instrumentation, laboratory instrumentation and miscellaneous instrumentation.

a) Sample Panel Instrumentation

Sample panels were provided to centralize various parameters within their associated system. The following sample panels were provided:

- Units No. 1 and 2 Sample Panels which monitor oxygen, pH, conductivity, ammonia, silica and phosphate at various sample points. Appendix B

- Units No. 3 and 4 Sample Panels which monitor oxygen, pH, conductivity, sodium and silica at various sample points. Appendix D

- Makeup Water Panel which monitors pH, turbidity, hardness, silica and sodium at various sample points. Appendix F

b) Laboratory Instrumentation

Both new and replacement analytic laboratory instrumentation was provided to allow the chemistry department to improve and maintain various process

systems within the plant. The following instrumentation was provided: Appendix G

- ion chromatograph which measures Cl, SO_4, NO_3, Na, Ca and Mg
- UV - visible spectrophotometer which measures SiO_4, PO_4 and NH_3
- pH meter
- conductivity meter
- portable pH/conductivity meter
- oil moisture meter
- hydrogen moisture meter
- hydrogen purity meter
- oil viscosity meter

c) Miscellaneous Instrumentation

Various new and replacement critical parameters throughout the plant, such as flue gas oxygen analyzer, needed to be monitored and the following instrumentation was installed.

- Condensate Storage Tank(s) Panel G1 which monitors conductivity. Appendix H
- Makeup Water Treatment Panel G2 which monitors H_2SO_4 and NaOH concentration. Appendix H
- Mazut Transfer Pump Lube Oil Cooler Panel G3 which monitors the cooling water outlet for mazut contamination. Appendix H
- Mazut Heater Condensate Panel G4 which monitors the condensate leaving the heater for mazut contamination. Appendix H
- District Heating Water Inlet and Outlet Panels G5 and G6 which monitor oxygen, pH and calcium/magnesium (hardness). Appendix H

- Makeup Water Clarifier Panel G7 which monitors pH and turbidity. Appendix H

- Oxygen analyzer for boiler flue gas. Appendix I

- Oxygen analyzer for makeup water for heating deaerators. Appendix H

- Conductivity analyzer for district heating water heat exchanger condensate return. Appendix H

- Oil analyzer for gland steam condenser condensate. Appendix H

- Oil analyzer for turbine lube oil cooler cooling water outlet. Appendix H

- H_2SO_4 and NaOH concentration analyzers for the Condenser Polisher. Appendix H

- H_2SO_4 and NaOH concentration analyzers for the Boiler Water Makeup Demineralizer. Appendix H

- NaCl analyzer for cation exchangers. Appendix H

- Mazut flow meters. Appendix I

- H_2SO_4 Storage Tank level gages. Appendix I

- NaOH Storage Tank level gages. Appendix I

As a result of the new instrumentation the following improvements/benefits were achieved:

- fuel economy improved by maintaining the correct O_2 concentration in the flue gas as a result of the O_2 analyzer

- increased instrument response time - Appendix J

- increased accuracy - Appendix J

- user friendly - Appendix J

- easier to maintain - Appendix J
- reduce manhours by decreasing manual sampling frequency to check instrument accuracy and response time - Appendix J
- increased safety of personnel
- instrumentation has the ability to be an input for future automatic control
- on-line, real time trending capability
- compact

4. General Hardware

In order to help Kiev 5 CHP personnel to continue to maintain their plant in a high level of operation various general hardware items were provided:

- tools (wrenches, pliers, ratchets, sockets, etc.)
- fasteners (bolts, nuts, washers)
- gasket materials
- valve and pump packing

B. TRAINING

Hands-on training on the various plant instrumentation was provided by Waters Equipment Company's field service engineer/technician during eight weeks of technical startup assistance. This allowed Kiev-5 maintenance and operations personnel to become familiar/comfortable with the new instrumentation.

Additional assistance was provided by Dow Chemical's field service engineer/technician to allow Kiev-5 water treatment personnel to establish various backwash and regeneration flowrates to optimize the performance of the ion resins.

III CONCLUSIONS

Benefits derived from the program are substantial though wide and varied.

The biggest contributor to the derived benefits was the installation of new ion exchanger resin. However, to maintain and maximize these benefits required the use of some of the new plant instrumentation. Generally speaking, the new resins increased water quality, decreased scaling and fouling of heat transfer surfaces. This results in less fuel being consumed for the same power output thus reducing NO_x, SO_2, CO_2 and thermal emissions.

The following improvements/benefits were achieved:

- Increased operational flexibility by increasing ion exchange vessel throughput (the amount of water produced between regenerations). Besides less regenerations, therefore less chemical reagents and less waste water discharged into the environment, increased throughput allows maintenance more time to correct any problems which may occur to an ion exchange vessel before the vessel is needed again. Appendix K

- Improved turbine generator performance by reducing the rate of turbine generator degradation by lowering the silica content by 37% in the steam supplying the turbine generator.

- With the installation of level indicating transmitter for both the sulfuric acid, H_2SO_4 storage tanks (3) and the sodium hydroxide, NaOH storage tanks (3) resulted in improved personnel safety. Prior to the installation of new instrumentation, plant personnel would climb on top of the storage tank and remove the manway cover and visually determine the level subjecting themselves to hazardous fumes and the possibility of falls. Additionally, level alarms are also installed to notify plant personnel that a tank may be in imminent danger of overflowing.

- Reduced plant expenditures due to eliminating boiler acid blowdowns. Appendix L

- Reduced plant expenditures due to the reduction of chemical reagents. Appendix M

- Reduced plant expenditures due to burning less mazut. Appendix N

- Historically, Kiev-5 knew the total amount of fuel the four (4) units burned but did not have the instrumentation to determine how much fuel each unit burned. This created an operational dilemma because if they had to reduce electrical output they did not know which unit to reduce load on. With the addition of new mazut flow meters Kiev-5 can conduct efficiency tests to determine unit efficiency at 25%, 50%, 75% and 100% load. It is possible for a unit to be more efficient at 75% load but less efficient at 100% load than another unit. This can also be true for other loads. Therefore, they can determine which unit to reduce load on, thus achieving maximum efficiency.

- Total estimated annual cost benefits of $905,000. Appendix O

Environmental Benefits

- reduced total chemical reagent use by 38.9% from 1780 tons/yr to 1087.5 tons/yr. Appendix K

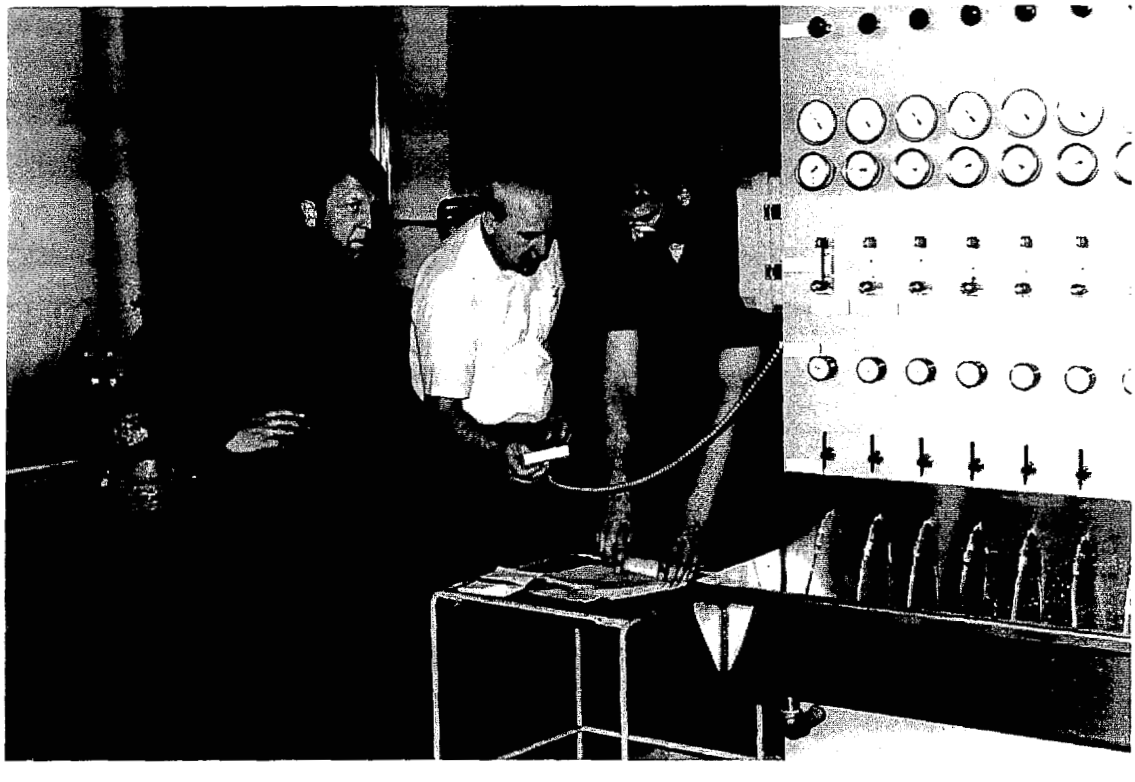
  - H_2SO_4 10% reduction 15 tons/yr
  - NaOH 25% reduction 37.5 tons/yr
  - NaCl 30% reduction 360 tons/yr
  - HCl 100% reduction 280 tons/yr (due to no boiler acid blowdowns)

- reduced volume of waste water discharging into the Dnieper River by 25%, from 500,000 m^3/yr to 375,000 m^3/yr. Appendix K

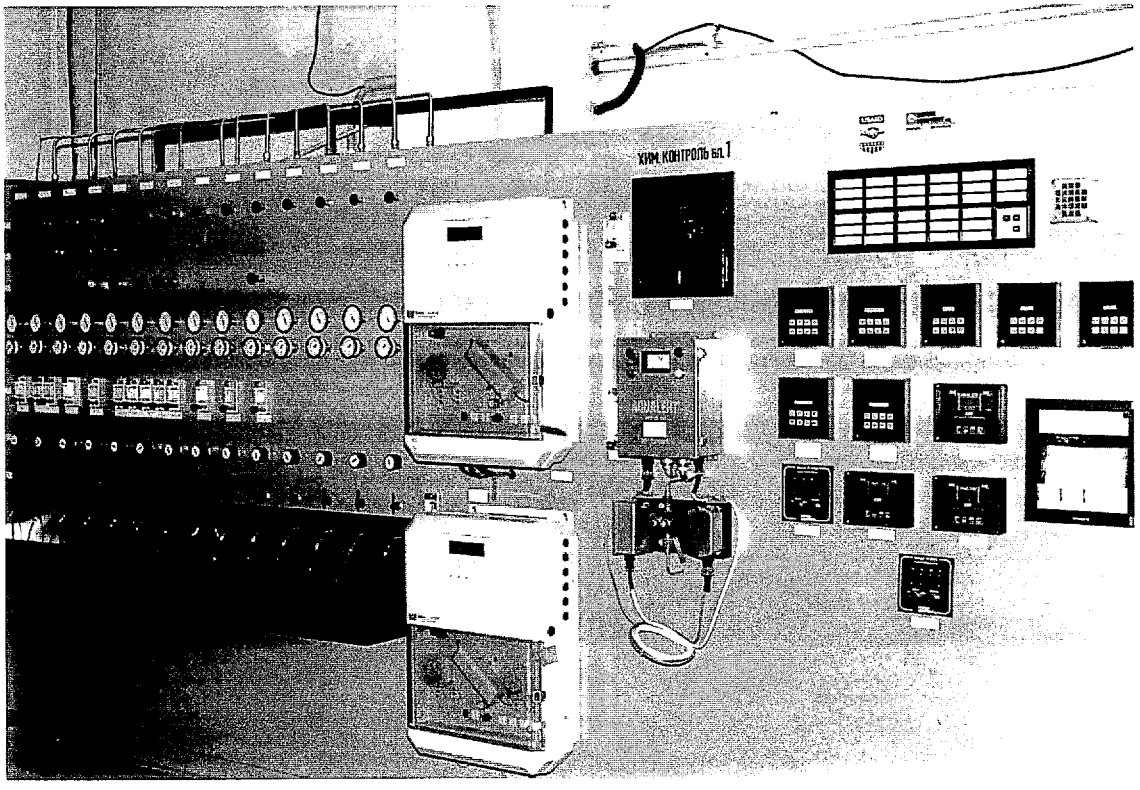
- reduced the amount of greenhouse gases, such as NO_x, CO_2 and SO_2, corresponding to burning 368 less tons/yr of mazut; due to increased water quality resulting in a significant reduction of scaling and fouling of heat transfer surfaces. See Appendix N

- reduced the amount of thermal pollution corresponding to burning 368 less tons/yr of mazut due to increased water quality resulting in a significant reduction of scaling and fouling of heat transfer surfaces. See Appendix N

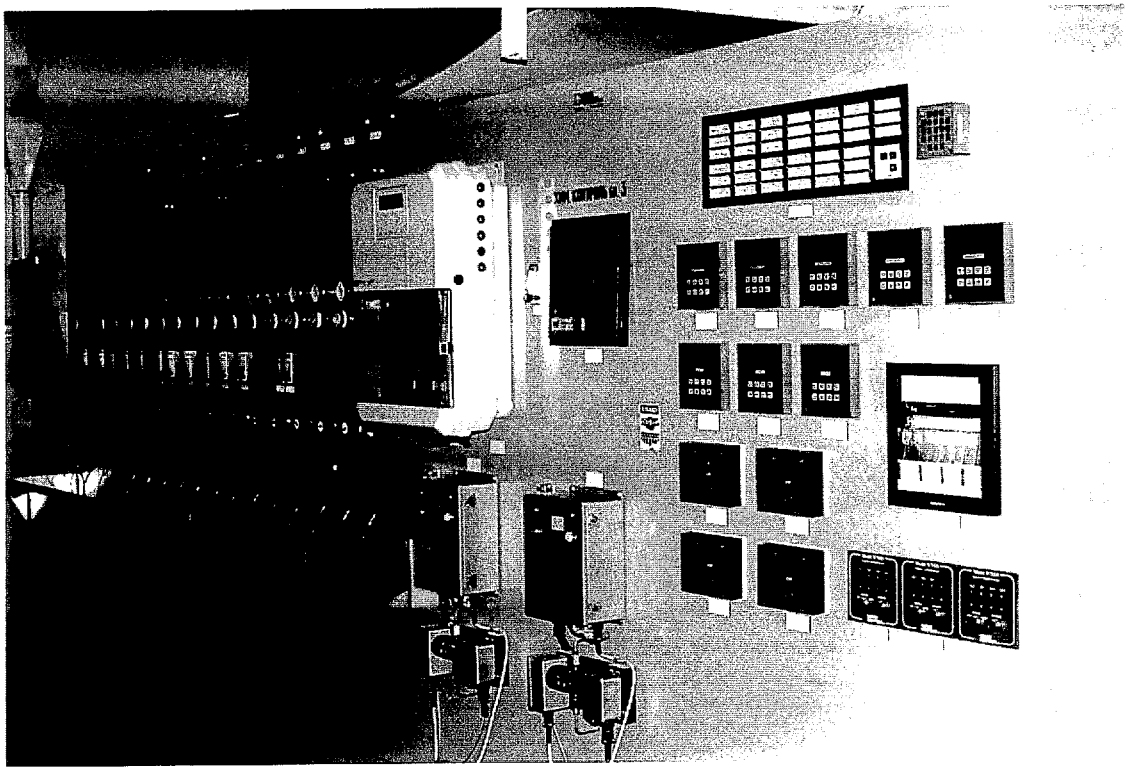
RIBBON CUTTING CEREMONY WITH U.S. AID AND KIEVENERGO
REPRESENTATIVES HELD ON JULY 8, 1997



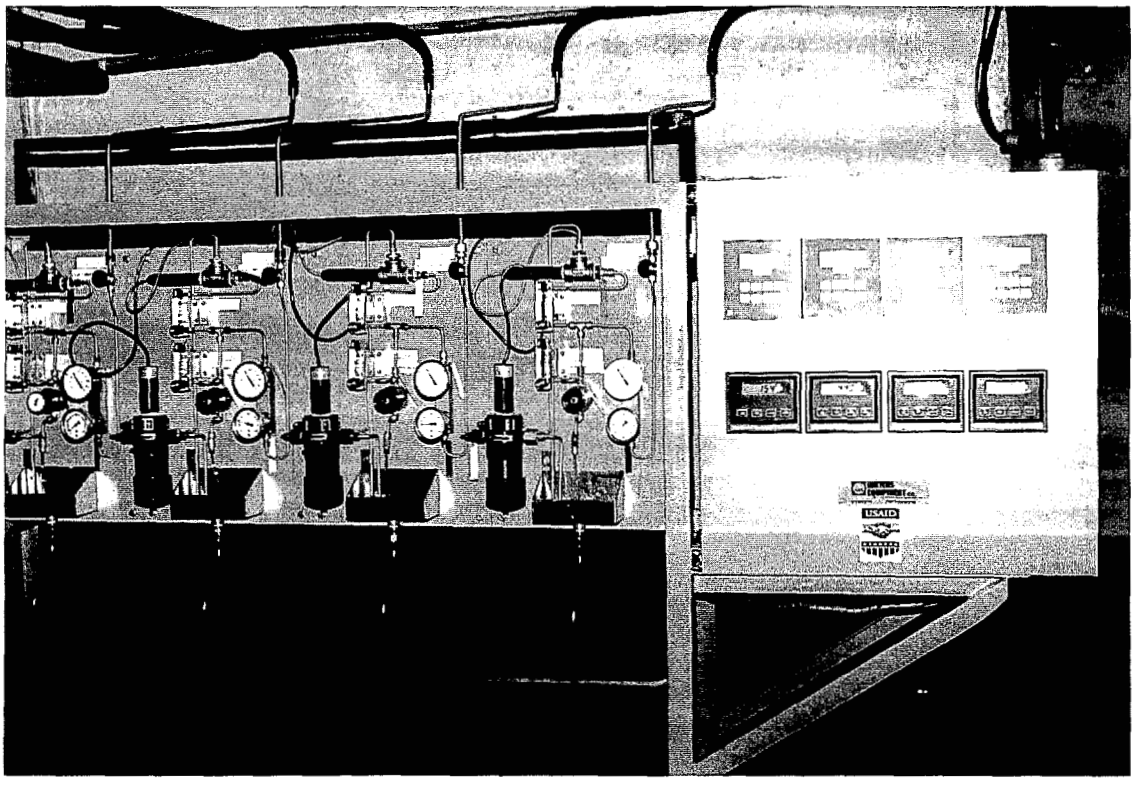
WATERS EQUIPMENT COMPANY
SERVICE ENGINEER/TECHNICIAN TRAINING PLANT PERSONNEL



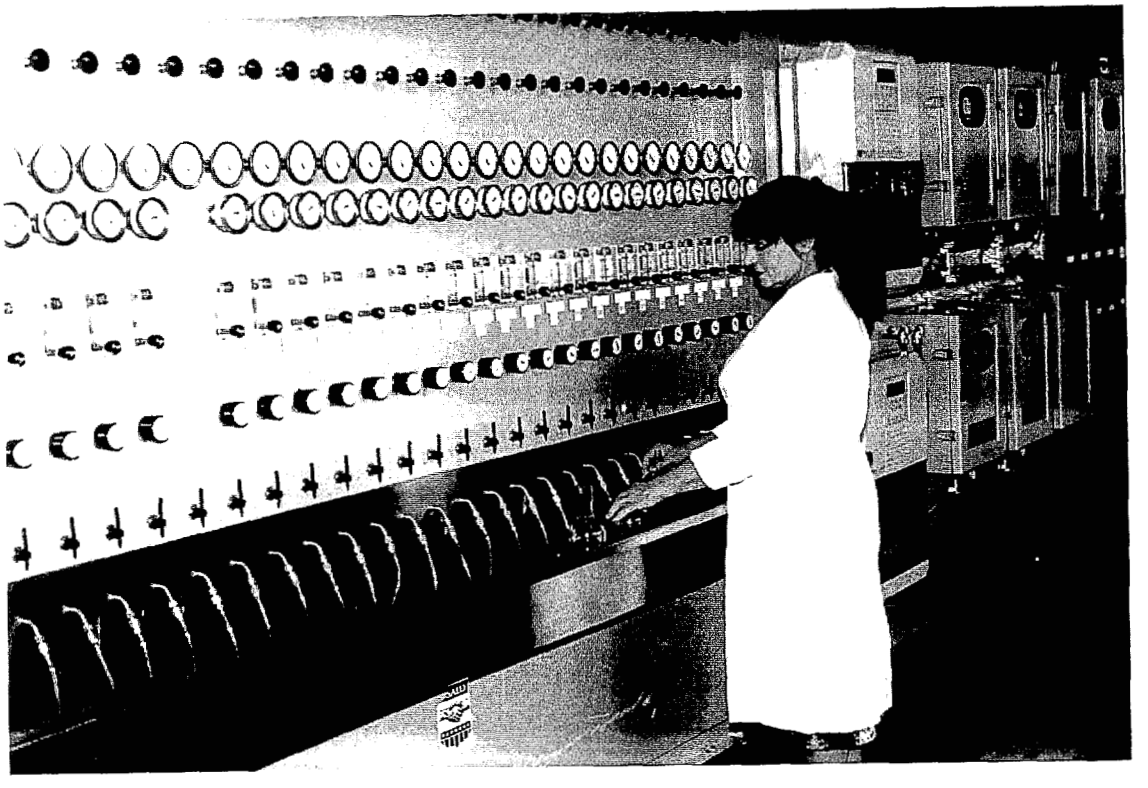
UNIT NO. 1 SAMPLE PANEL



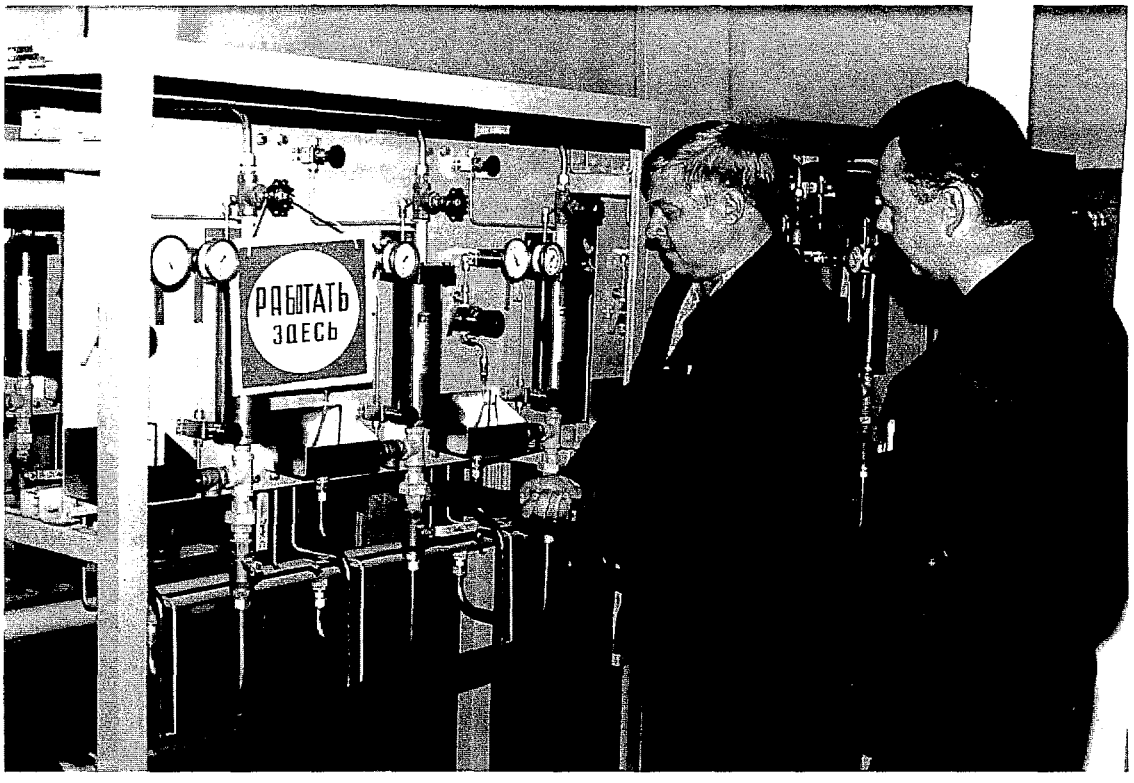
UNIT NO. 3 SAMPLE PANEL



WATER TREATMENT SAMPLE PANEL



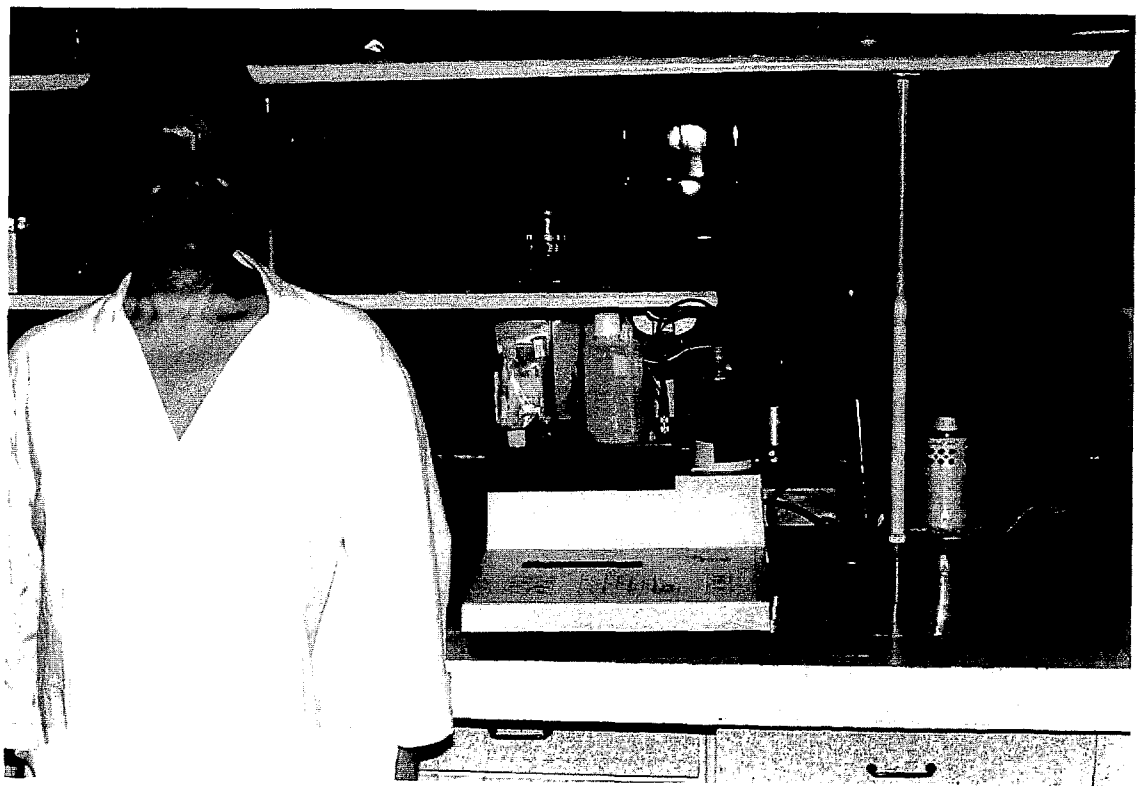
MAKE-UP WATER SAMPLE PANEL



KIEV-5 MAINTENANCE PERSONNEL USING WRENCH
THAT WAS PART OF THE NEW GENERAL HARDWARE

NaOH AND H_2SO_4 STORAGE TANK LEVEL INDICATORS

LABORATORY INSTRUMENTATION



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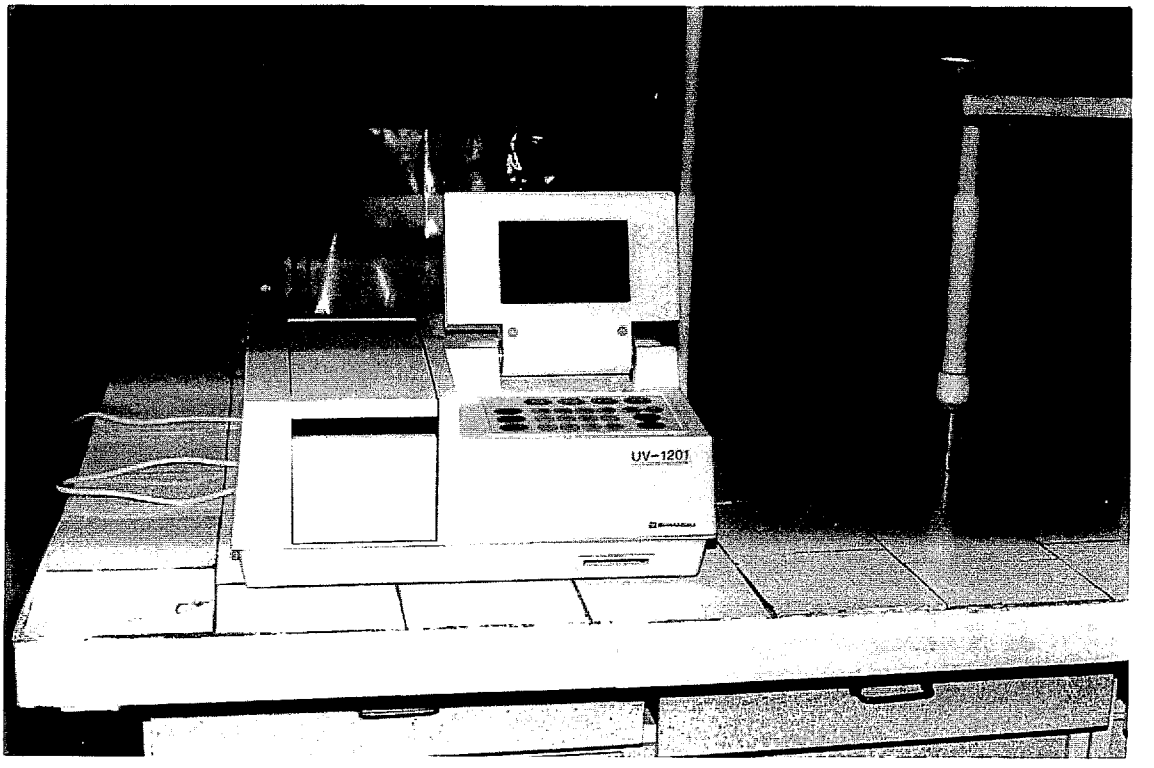
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U.S. aid helps improve Kyiv power station

KYIV — U.S. aid officials and representatives of the Kyivenergo power company marked the completion of a project to upgrade one of the capital's power plants with a ribbon cutting ceremony Tuesday July 8.

Kyiv combined heating and power plant (CHP) No 5 has been extensively refitted to improve its reliability and energy efficiency, and reduce its impact on the environment, according to a United States Agency for International Development press release.

Experts from the U.S. energy firm Burns and Roe implemented the USAID funded project, working together with officials from CHP No 5 and Kyivenergo to assess the plant's technical needs; provide the requisite technology and oversee its installation.

In particular, the U.S. company provided modern ion exchange resins, used to demineralize water used in the plant's boilers, and soften water used in the district heating system.

Apart from upping CHP No 5's performance, the new ion exchange resins have brought numerous other benefits, according to staff at the plant. Water wastage has been reduced, and waste water discharges into the Dnipro river have been cut in both frequency and volume. Added to that, internal scaling on the plant's piping and boilers has been reduced, bringing a corresponding reduction in the level of boiler maintenance needed. Illustrating the point, CHP No 5 Chief Engineer Nikolai Danileno said none of the plant's eight boilers have had to be shut down for cleaning since 1995. Previously, each boiler had to be shut down for cleaning for three days every year.

Burns and Roe also oversaw the installation of modern equipment at the plant to monitor water quality and improve the performance of water treatment processes, the press release said.

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11

APPENDICES

Appendix A - Water Treatment Plant
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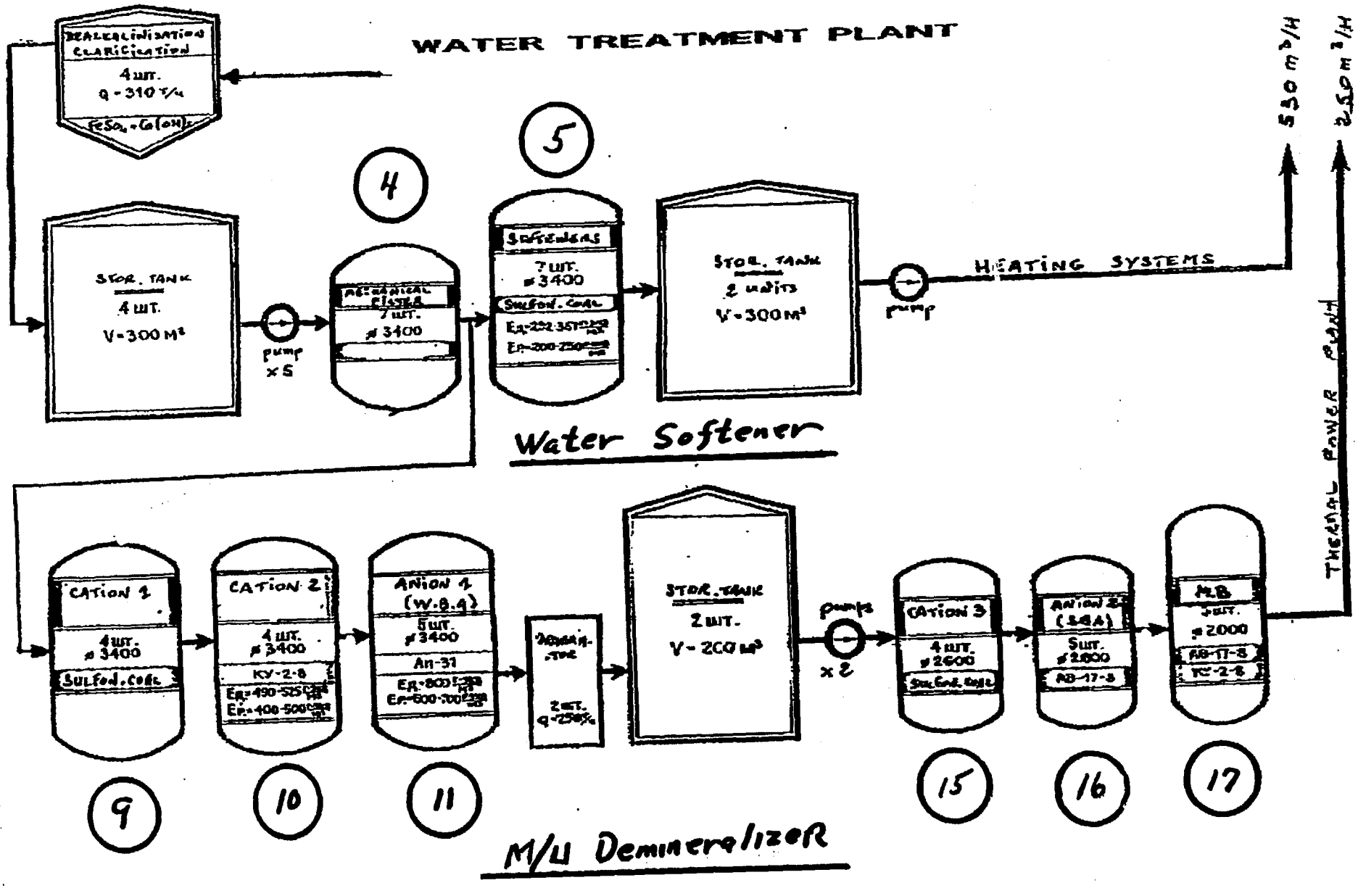


APPENDIX A

APPENDIX B

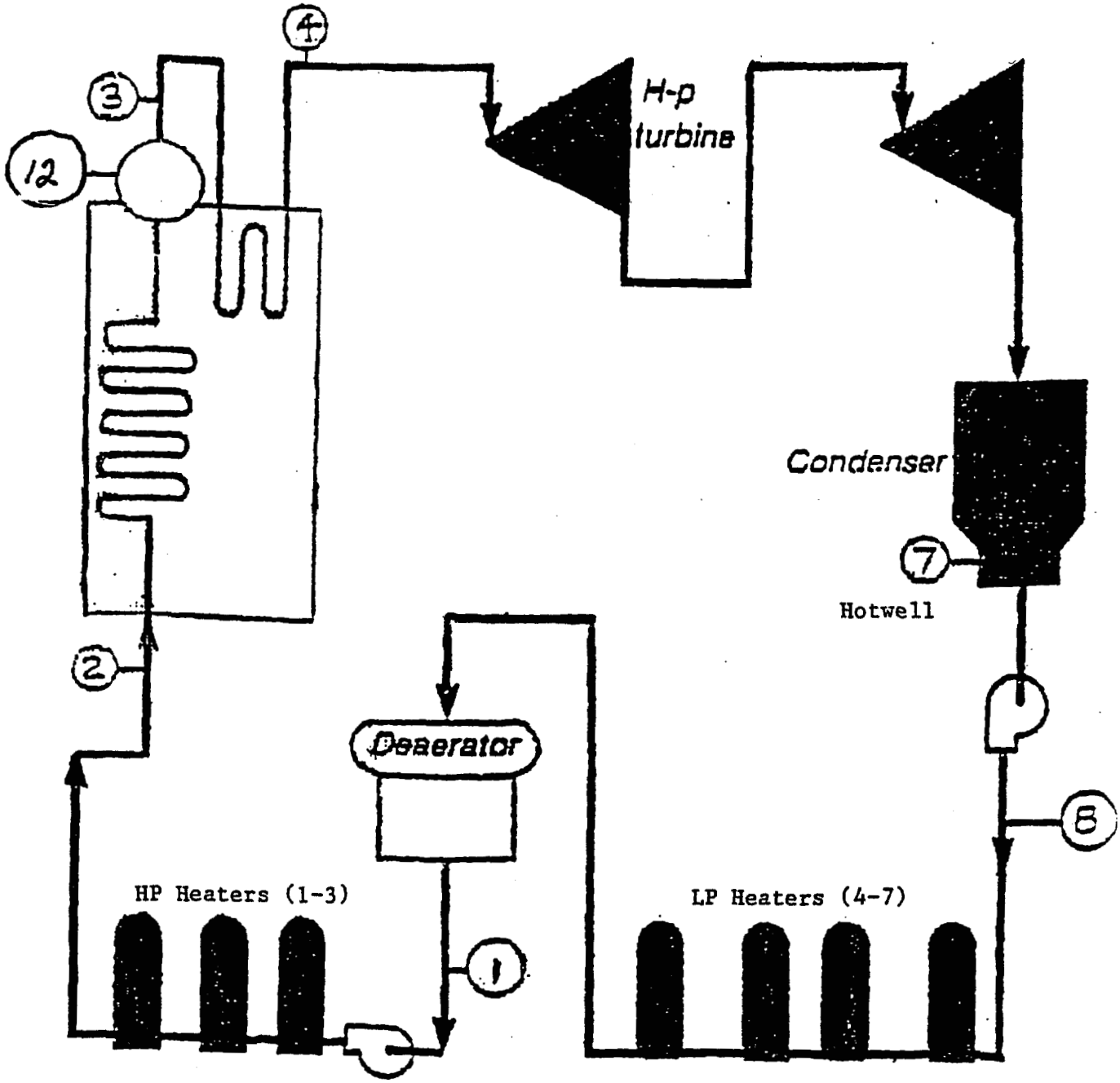
UNITS 1 & 2 - DRUM TYPE BOILERS
PARAMETERS AND SAMPLE POINTS FOR ON-LINE SAMPLING INSTRUMENTATION

SAMPLE POINT NO.*	DESCRIPTION SAMPLE POINTS	NO. REQ'D.	MEASURED PARAMETER	INSTRUMENT RANGE	MEASURED UNITS	PROCESS PRESSURE	PROCESS TEMP.	LINE MATERIAL	LINE SIZE ϕ	LINE THICK.	REMARKS
1	FEEDWATER AFTER DEAERATOR	1	O_2	0-5	µg/kg (ppb)	8 atm (118 psia)	158°C (316°F)	Carbon Steel 0.2%C			
2	FEEDWATER BEFORE ECONOMIZER	1 1 1	pH N_2H_4 CAT Conductivity	8.5-11.5 10-100 0-2	pH µg/kg (ppb) µs/cm	161 atm (2367 psia)	230°C (446°F)	Carbon Steel 0.15%C <1% Mn	326mm		
3	SATURATED STEAM	1 1	SiO_2 CAT Conductivity	0-60 0-1	µg/kg (ppb) µs/cm	156 atm (2293 psia)	343°C (649°F)	Carbon Steel 0.16%C <1% Ni <1%Mo	1700 mm		
4	SUPERHEATED STEAM BEFORE TURBINE	1 1	SiO_2 CAT Conductivity	0-60 0-1	µg/kg (ppb) µs/cm	131 atm (1926 psia)	560°C (1040°F)	Carbon Steel 0.12%C 1% Cr <1% Mo	328 mm		
5 & 6	NOT USED										
7	CONDENSATE HOTWELL	1	CAT Conductivity	0-10	µs/cm	.13 atm (1.91 psia)	45°C (113°F)	Carbon Steel 0.2%C	179 mm		
8	CONDENSATE AFTER PUMPS	1 1 1	pH O_2 CAT Conductivity	8.0-10.0 0-5 0-10	pH µg/kg (ppb) µs/cm	17 atm (250 psia)	45°C (113°F)	Carbon Steel 0.2%C	326 mm		
10 & 11	NOT USED										
12	STEAM DRUM INCLUDING: STEAM DRUM INBOARD SEPARATOR WATER SEPARATOR STEAM STEAM DRUM TO SH	1 1 1 1	pH Conductivity SiO_2 Phosphate	8.5-11.5 0-100 0-5 0-30	pH µs/cm µg/kg (ppb) µg/kg (ppb)	156 atm (2293 psia)	343°C (649°F)	Carbon Steel 0.12%C 1% Cr <1%Mo	32 mm		

* See Appendix C

NOTES: 1. Sample points and related data is identical for Unit 1 and Unit 2.

APPENDIX C



UNITS 1 + 2

APPENDIX D

UNITS 3 & 4 - SUPERCRITICAL BOILERS

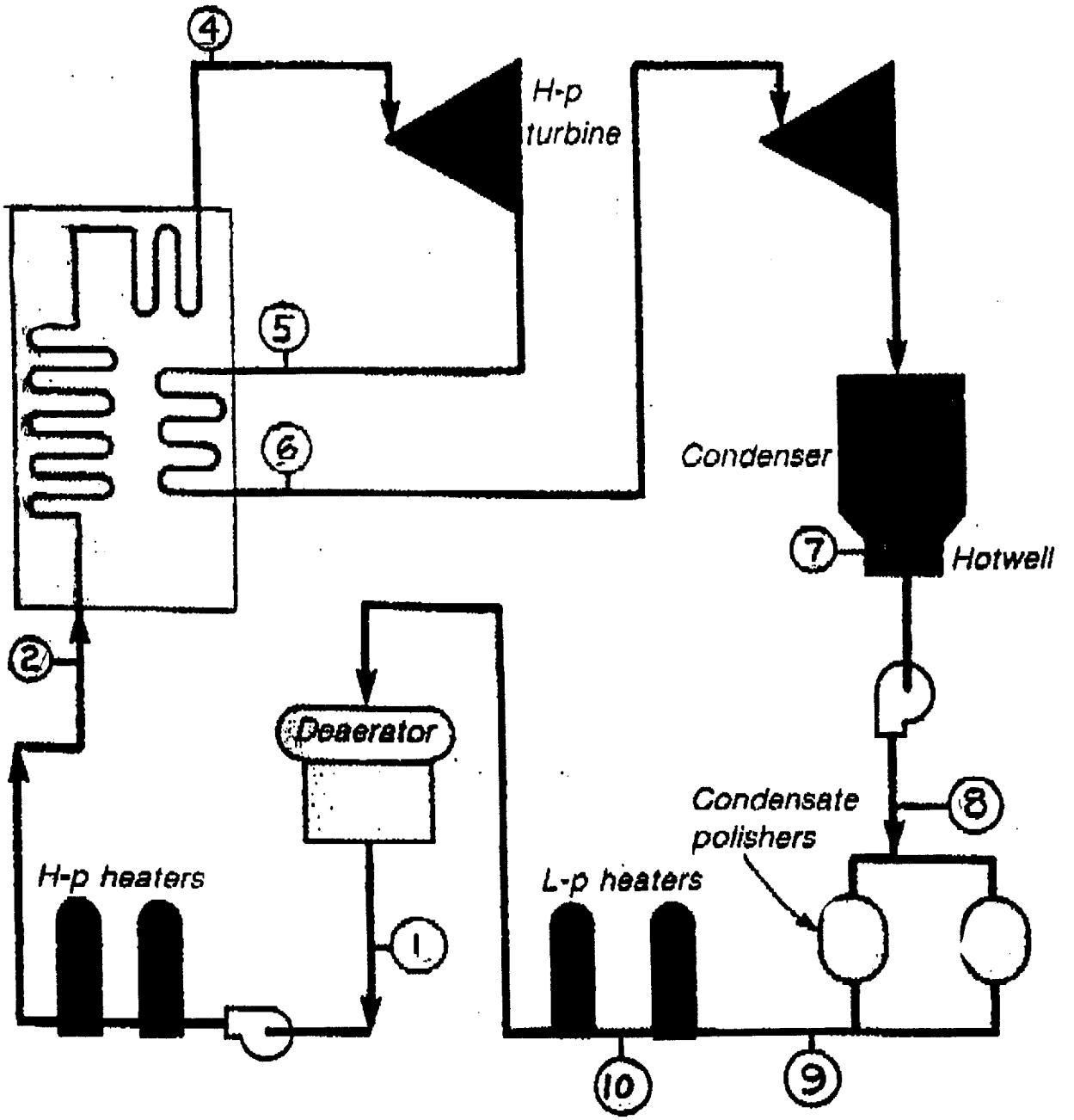
PARAMETERS AND SAMPLE POINTS FOR ON-LINE SAMPLING INSTRUMENTATION

SAMPLE POINT NO.*	DESCRIPTION SAMPLE POINTS	NO. REQ'D.	MEASURED PARAMETER	INSTRUMENT RANGE	MEASURED UNITS	PROCESS PRESSURE	PROCESS TEMP.	LINE MATERIAL	LINE SIZE ϕ	LINE THICK.	REMARKS
1	FEEDWATER BEFORE FEED PUMPS (DEAERATOR OUTLET)	1	pH	5.0-9.0	pH	9 atm (132 psia)	164°C (327°F)	Carbon Steel 0.2%C	600 mm		
2	FEEDWATER BEFORE ECONOMIZER	1 1 1 1 1	O_2 pH Na^+ SiO_2 Conductivity	0-300 6.0-9.0 0-1.0 0-100 0-0.5	µg/kg (ppb) pH mg/kg (ppm) µg/kg (ppb) µs/cm	266 atm (3910 psia)	265°C (509°F)	Carbon Steel 0.15%C	377 mm	45 mm	
3	NOT USED										
4	SUPERHEATED STEAM BEFORE TURBINE	1 1 1	Na^+ SiO_2 Conductivity	0-1.0 0-100 0-0.5	mg/kg (ppm) µg/kg (ppb) µs/cm	256 atm (3763 psia)	545°C (1013°F)	Carbon Steel 0.15%C 1% Cr 1% Mo <1%V	325 mm	60 mm	
5	COLD REHEAT STEAM	1 (Unit 4 Only)	Conductivity	0-1	µs/cm	41.3 atm (607 psia)	297°C (567°F)	Carbon Steel 0.12%C	465 mm	16 mm	
6	HOT REHEAT STEAM	1 (Unit 3 Only)	Conductivity	0-1	µs/cm	38.8 atm (570 psia)	545°C (1013°F)	Carbon Steel 0.2%C	630	22 mm	
7	CONDENSATE HOTWELL	1	Conductivity	0-1	µs/cm	0.13 atm (1.91 psia)	45°C (113°F)	Carbon Steel 0.2%C	219 mm		
8	UNIT DEMINERALIZER CONDENSATE INLET	1 1 1	SiO_2 Conductivity Conductivity	0-100 0-10 0-1	µg/kg (ppb) µs/cm µs/cm	9 atm (135 psia)	45°C (113°F)	Carbon Steel 0.2%C	600 mm		
9	UNIT DEMINERALIZER CONDENSATE OUTLET	1 1 1	Na^+ SiO_2 Conductivity	0-1 0-100 0-1	mg/kg (ppm) µg/kg (ppb) µs/cm	9 atm (135 psia)	45°C (113°F)	Carbon Steel 0.036%	400 mm		
10	CONDENSATE AFTER LP HEATER (BEFORE DEAERATOR)	1	O_2	0-100	µg/kg (ppb)	13-16 atm (235 psia)	145°C (293°F)	Carbon Steel 0.2%C	426 mm		

* See Appendix E

NOTES: 1. Sample points and related data is identical for Unit 3 and Unit 4, unless indicated otherwise.

APPENDIX E



UNITS 3 + 4

APPENDIX F

MAKEUP WATER TREATMENT SYSTEM
PARAMETERS AND SAMPLE POINTS FOR ON-LINE SAMPLING INSTRUMENTATION

SAMPLE POINT NO.*	DESCRIPTION SAMPLE POINTS	NO. REQ'D.	MEASURED PARAMETER	NORMAL RANGE	MEASURED UNITS	PROCESS PRESSURE	PROCESS TEMP.	LINE MATERIAL	LINE SIZE ϕ	LINE THICK.	REMARKS
1	RAW WATER	1 1	pH Turbidity	6.5-8.5 0-100	pH NTU	8 atm (118 psia)	30°C (86°F)	CTA A63	300 mm	6 mm	
2A,2B,2C, 2D	CLARIFIER	1 ea. 1 ea.	pH Turbidity	9-11.5 0-20	pH NTU	1 atm (14.71 psia)	30°C (86°F)	----	----	8 mm	
3A,3B,3C, 3D,3E,3F,3 G, 3H	SOFTENERS (Na^+R): SOFTENERS BED COMMON INFLUENT	 1 ea. 1	 Hardness Hardness	 0-5 0-200	 mg/kg (ppm) mg/kg (ppm)	8 atm (118 psia)	30°C (86°F)	----	----	----	
4A,4B,4C, 4D	CATION II (H^+R)	1 ea.	pH	2-4	pH	8 atm (118 psia)	30°C (86°F)	----	----	----	
5A,5B,5C, 5D,5E	ANION I (ROH^-)	1 ea.	Conductivity	0-100	µs/cm	8 atm (118 psia)	30°C (86°F)	----	----	----	
6A,6B,6C, 6D	CATION III (H^+R)	1 ea.	pH	4-7	pH	8 atm (118 psia)	30°C (86°F)	----	----	----	
7A,7B,7C, 7D,7E	ANION II (ROH^-)	1 ea. 1 ea.	SiO_2 Conductivity	0-300 0-10	µg/kg (ppb) µs/cm	8 atm (118 psia)	30°C (86°F)	----	----	----	
8A,8B,8C	MIXED BED	1 ea. 1 ea. 1 ea. 1 ea.	pH Na^+ SiO_2 Conductivity	6.8-7.1 ≤ 15 ≤ 20 ≤ 0.5	pH ppb ppb µs/cm	8 atm (118 psia)	30°C (86°F)	----	----	----	

* See Appendix P

APPENDIX G

LABORATORY INSTRUMENTATION

DESCRIPTION	NO. REQUIRED	INSTR RANGE	MEASURED PARAMETER
ION CHROMATOGRAPH	1	0-1000 ppt*	Cl, SO_4, NO_3, Na, Ca, Mg
UV-VISIBLE SPECTROPHOTOMETER	1	0-100 ppm	SiO_4, PO_4, NH_3
pH METER	3		pH
CONDUCTIVITY METER	3	0-1000 µs	Conductivity
HANDHELD pH & CONDUCTIVITY METER	3	0-1000 µs	pH & Conductivity
OIL MOISTURE METER	1	0-0.005%	
HYDROGEN MOISTURE METER (BY TEMPERATURE DEW-POINT)	2	0-50	
HYDROGEN PURITY METER	2	0-100% H_2	
VISCOSITY METER (FOR OILS)	2	0-150 SST	

* parts per trillion

APPENDIX H

MISCELLANEOUS ANALYTICAL INSTRUMENTATION PARAMETERS AND SAMPLE POINTS FOR ON-LINE SAMPLING

SAMPLE POINT NO.	DESCRIPTION SAMPLE POINTS	NO. REQ'D.	MEASURED PARAMETER	INSTRUMENT RANGE	MEASURED UNITS	PROCESS PRESSURE	PROCESS TEMP.	LINE MATERIAL	LINE SIZE ϕ	LINE THICK.	REMARKS
	MAKEUP WATER FOR HEATING VAC. DEAERATORS		O_2	0-100	µg/kg (ppb)	2.5 atm (36.8 psia)	45°C (113°F)	Carbon Steel 0.2%C	400 mm		(NOTE 1)
1A	UNIT NO. 1 & 2	1									Subsystem 1
1B	UNIT NO. 3 & 4	1									Subsystem 3
	LP EXT. COND. FROM DIST. WTR. HEAT EXCH:	1 ea.	Conductivity	0-10	µs/cm	18 atm	40°C				(NOTE 1)
2A,2B, 2C,2D, 2E,2F, 2G,2H											Subsystem 1 Subsystem 2 Subsystem 3 Subsystem 4
	CONDENSATE STORAGE TANKS		Conductivity	0-10	µs/cm	1.8 atm (26.5 psia)	30°C (86°F)	G 3	8 m		(NOTE 2)
3A	TANK NO. 1	1									
3B	TANK NO. 2	1									
3C	TANK NO. 3	1									
3D	LOOSE UNIT	1									
	CONDENSATE FROM GLAND STEAM CONDENSERS		Oil	0-15	mg/kg (ppm)	0.15 atm (2.2 psia)	70°C (158°F)	Carbon Steel 0.2%C	159 mm		(NOTE 1)
4A	UNIT 3	1									Subsystem 3
4B	UNIT 4	1									Subsystem 4
	GENERATOR STATOR COOLING WATER		pH	6.5-11.5	pH	4.5 atm (66.2 psia)	33°C (91°F)	G	100 mm		(NOTE 1)
	UNIT 3	1 ea.	O_2	0-500	µg/kg (ppb)						
	UNIT 4	1 ea.	Conductivity	0-5	µs/cm						
5A											Subsystem 3
5B											Subsystem 4
	L.O. CLG. WTR. OUTLET:	1 ea.	Oil	0-15	mg/kg (ppm)	0-1.65 atm (24.3 psia)	28°C (82°F)	G 3	250 mm		(NOTE 1)
6A,6B,6C,6D, 6E,6F,6G,6H											Subsystem 1 Subsystem 3
7	COND. POLISHER	1	H_2SO_4 Conc.	0-5	%	6 atm	50°C				(NOTE 4)
		1	NaOH Conc.	0-5	%						
8	SOFTENER	1	H_2SO_4 Conc.	0-5	%	6 atm	50°C				(NOTE 4)
9A,9B,9C	DEMIN. MUP WATER	1 ea.	H_2SO_4 Conc.	0-5	%	6 atm	50°C				(NOTE 4)
		1 ea.	NaOH Conc.	0-5	%						

APPENDIX H (continued)

MISCELLANEOUS ANALYTICAL INSTRUMENTATION PARAMETERS AND SAMPLE POINTS FOR ON-LINE SAMPLING

SAMPLE POINT NO.	DESCRIPTION SAMPLE POINTS	NO. REQ'D.	MEASURED PARAMETER	INSTRUMENT RANGE	MEASURED UNITS	PROCESS PRESSURE	PROCESS TEMP.	LINE MATERIAL			
10	REGEN Na	1	NaCl	0-5	%	6 atm	30°C				(NOTE 4)
11	CATION FILTERS	1	NaCl	0-5	%	6 atm	30°C				(NOTE 4)
12A,12B	Mazut Transfer Pump Lube Oil Cooler	1	Oil	0-15	mg/kg (ppm)	6 atm	60°C				(NOTE 5)
13A,13B,13C, 13D,13E,13F	Mazut Heater Condensate	1	Oil	0-15	mg/kg (ppm)	4 atm	150°C				(NOTE 6)
	DISTRICT HEATING:										(NOTE 7)
14A,14B,	WATER INLET	1	0_2	0-100	µg/kg (ppb)	25 atm	90°C				
14C,14D,		1	pH	8.5-10.0	pH	(367.5 psia)	(194°F)				
14E,14F,		1	Ca/Mg	<1.5	mg/kg (ppm)						
14G,14H,	WATER OUTLET	1	0_2	0-100	µg/kg (ppm)						
14I,14J,		1	pH	8.5-10.0	pH						
14K,14L		1	Ca/Mg	<1.5	mg/kg (ppm)						

NOTES:

1. The sample is conditioned and monitored/controlled from panels dedicated to subsystems identified here.
2. The samples are analyzed and monitored locally.
3. The samples are analyzed locally. Output of the analyzer associated with 6A,6B,6C, and 6D will be recorded and alarmed on subsystem 1 panel. Output of the analyzer for 6E,6F,6G and 6H will be recorded and alarmed on subsystem 3 panel.
4. The samples are analyzed locally. Output of the analyzers will be recorded and alarmed on a common recorder and common annunciator mounted on subsystem 5 panel.
5. The samples are analyzed locally by a common analyzer. Analyzer output will be recorded and alarmed locally.
6. The samples are analyzed sequentially by a local analyzer. Analyzer output will be wired to local recorder and annunciator assigned for sample points 12A and 12B.
7. The samples are analyzed sequentially by two local analyzers, such that samples from 14A, 14B, 14C, 14D, 14E and 14F are processed through one analyzer and samples from 14G, 14H, 14I, 14J, 14K and 14L are processed through other analyzer. The analyzer output will be recorded locally on a common recorder.

APPENDIX I

COMBUSTION AND FUEL INSTRUMENTATION

ITEM NO.	DESCRIPTION	QTY.	MAKE & MODEL NO.
1	H_2SO_4 Tank NaOH Tank Level Measuring Instrument	3	• Endress & Hausser Prosonic Level Transmitter, Model FMU862R1E1A or equal – dual channel unit – general purpose electrical qualification – integral controls & illuminated display – 2SPDT relay outputs, 4A at 250 VAC programmable – 220 VAC, 50 Hz powered – 4-20 mADC output – NEMA 4X enclosure
		6	• Endress & Hausser Prosonic Level Sensor, Model FDU81RN8B or equal – 29 feet range – 1" NPT connection – general purpose electrical qualification – 24 VDC heater, 10W – 100 feet sensor cable – external temp. Sensor
		1	• 24 VDC power supply for heaters
2	Mazut Supply Flow Meter (Pipe Dia. 325 mm)	2	Controlotron or equal • 994 NM4GS-3 (Qty. 1) Single channel NEMA 4X Flow Computer
		1	– local LCD display – totalizer – alarm relay output – 220 VAC, 50 Hz power supply • 995T1 (Qty. 1) Handheld Terminal (Control Display Unit) • 991 NMS-3 (Qty. 3) Metallic Transducer Pair • 992 MTNHMA (Qty. 3) Aluminum Mounting Track • 992CNS (Qty. 3) NEMA Transducer Cable Assembly w/100 feet cable • 994-8M (Qty. 2) Analog Data Function Module, Dual channel
3	Control Room Electronics for Oxygen Analyzer	2	Rosemount Model CRER 3000
4	Tubing	Bulk	
5	Tube Fittings	Bulk	

APPENDIX J

COMMENTS FROM KIEV-5 CHP PERSONNEL

Various plant personnel who use the items supplied by USAID were interviewed to ascertain the adequacy of items supplied. They were asked for both positive and negative feedback.

1) Nadezhda Sevalneva Ksenofontovna - Chief of Central Chemical Laboratory

   - instrumentation is very accurate, greater sensitivity, easier to use and portable

   - analysis of determining the amount of moisture in oil used to take 2 hours, now it takes approximately 10 minutes and it is more accurate

2) Vladimir Petrovich Gnatyuk - Chief of Automatic Controls Chemical Group

   - instrumentation is easier to maintain, reliable and accurate

   - expressed wish that <u>all</u> instrumentation vendor instructions be in Russian

3) Valeriy Shachazuk - Chief Chemical Engineer

   - typically, every 1 to 2 hours, technicians would normally take samples and analyze them; with the new equipment it is done once a day

   - typically, once a day as a backup, the central laboratory technician would manually take samples and analyze them; now they do this weekly

   - extremely happy with the performance of the resin as capacity and quality of water increased, chemical reagent use decreased

Many Kiev 5 personnel expressed a concern about acquiring consumable and spare parts after the initial quantities are exhausted.

Bur. and Roe Enterprises, In.
Kiev Office
20 Esplanadna St., Kiev 252023, Ukraine
Tel: (38044) 220 1676, 220 8752 Fax: (38044) 227 0200

Total pages 6

Date: October 4, 1995

Fax to: Alan Dempsey, B&R

Fax No. (101)(201) 986 4397

From: Alexander Filippov

Alan,

I contacted Kiev5 upon your request about effectiveness of implemented resins. Below is an information summary obtained from the plant. It was prepared by chemical workshop engineers of Kiev5. I am sending you an original document in Russian supplemented with my translation and some comments.

To A.Filippov, Burns and Roe resident in Ukraine.

Upon your request we represent the following preliminary results of functioning efficiency of Dow ion resins installed at Kiev-5 according to the project.

1. Main water quality characteristics:
a) Condensate Polisher (Units #3 and 4):
- conductivity:
before installation of resins -- 0.084 μcm/sq.sm;
after installation of resins -- 0,067 μcm/sq.sm;
Reduction: 8%

b) Make up Water Demineralizer:
- SiO_2:
before installation of resins -- 27 μg/kg;
after installation of resins -- 17 μg/kg;
Reduction: 1.6 times

- conductivity:
before installation of resins -- 0.1-0.12 μcm/sq.sm;
after installation of resins -- 0.08-0.1 μcm/sq.sm;
Reduction: 18%

APPENDIX K

c) Water Softening System:
- hardness of makeup water:
before installation of resins -- 570 μg-equiv./kg;
after installation of resins -- 288 μg-equiv./kg;
Reduction: 50%

- hardness of delivery water:
before installation of resins -- 933 μg-equiv./kg;
after installation of resins -- 650 μg-equiv./kg;
Reduction: 30%

2. Regeneration frequency and amount of regenerate chemicals:
a) Condensate Polisher:
- after changing ion resins regeneration frequency reduced 1.6 times, amount of acid and alkali per one ton of condensate reduced from 2 g/t to 1.4 g/t
Reduction: 30%

b) Make up Water Demineralizer:
- after changing ion resins regeneration frequency reduced 1.2-1.3 times, expenditure of ~~acid~~ reduced on 25% and ~~alkali~~ on 5%.
alkali acid.

c) Water Softening System:
- after changing ion resins regeneration frequency reduced average 2 times, expenditure of common salt reduced on 30%.

3. Throughput of resin vessels:
a) Condensate Polisher:
- before changing ion resins - 250000 cubic m;
- after changing ion resins - 400000 cubic m;

b) Make up Water Demineralizer:
- cation 1 stage
before changing ion resins - 3000 cubic m;
after changing ion resins - 5000 cubic m;

- anion 1 stage
before changing ion resins - 7000 cubic m;
after changing ion resins - 8000 - 10000 cubic m;

- cation 2 stage
before changing ion resins - 5000 cubic m;
after changing ion resins - 20000 cubic m;

- anion 2 stage
before changing ion resins - 9000 cubic m;
after changing ion resins - 10000 cubic m;

- mixed bed
  before changing ion resins - 50000 cubic m;
  after changing ion resins - 75000 cubic m.

4. Waste water decreased on 25% from 500000 to 375000 cub.m/year.

5. After installation of new resins the amount of waste condensate did not change but due to enhanced water quality there is no growth of salt scales on heating surfaces. Thus there is no need to conduct acid blowdowns of the plant main equipment.

On a basis of preliminary functioning data analysis the highest effect was reached in the water Softening System.

Director of Kiev5 S. Serdjuk

During the meeting with Mr. Zakharuk (the head of chemical dept.) I figured out also the following.

With old resins the plant had consumption of about 150 ton of sulfur acid, 150 ton of caustic soda and 1200 ton of common salt per year for filters regeneration. With new resins it is possible to save about 5-10% of acid, 25% of soda and 30% (and in reality it showed 50%) of salt.

The period between cleaning the main equipment of salt decreased from 1 to approximately 1.5 years.

I asked the question about the quality of the used water which goes to Dnieper river. The results of laboratory analysis show that quality increased although the difference between the general content of salt in the water before and after usage is about 4 times.

By the moment the plant has substituted approximately 80% of old resins and plan to finish the process of changing during this winter.

I am ready to answer any of your possible questions. Especially sorry for possible drawbacks of my translation particularly relating some chemical terms.

Best regards,

Alex.

УКРАЇНА
МІНІСТЕРСТВО ЕНЕРГЕТИКИ
І ЕЛЕКТРИФІКАЦІЇ УКРАЇНИ
ВЕО „КИЇВЕНЕРГО"
КИЇВСЬКА ТЕЦ-5

Індекс 252013, м. Київ-13, вул. Промислова, 4
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Телефон 269-93-11, приймальна 269-93-59
Р-р 000221011 в Старокиївському ПІБ м. Киева
МФО 322227

_____ № _____

На № _____

Burns and Roe

Представителю в Украине
А.Филиппову
252023, г.Киев, ул.Эспланадная, 20

Сообщаем следующие предварительные результаты эффективности работы ионообменных смол DoW на Киевской ТЭЦ-5 поставленных согласно проекта

I. По основным показателям качества:

а/ конденсатоочистки блоков №№ 3,4:

электропроводность:

до замены смол - 0,084 мксм/см2

после замены - 0,067 мксм/см2

/снижение на 8%/

б/ химводоочистки:

- содержание двуокиси кремния:

до замены смол - 27 мкг/кг

после замены - I7 -"- /снижение в I,6 раза/

- электропроводность:

до замены смол - 0,I÷0,I2 мксм/см2

после замены - 0,08÷0,I -"- /снижение на I8%/

в/ системы умягчения воды:

- жесткость подпиточной воды:

до замены смол - 570 мкг-экв/кг

после замены - 288 -"- /снижение на 50%/

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О. П. «Кагарлицька друкарня», З. 564—3000 95

- жесткой сетевой воды:

до замены смол - 933 мкг-экв./кг

после замены - 650 -"- /снижение на 30%/

II. Частота регенераций и количество реагентов:

а/ конденсатоочистки:

- после замены ионитов частота регенераций снизилась в I,6 раза, количество кислоты и щелочи на одну тонну конденсата уменьшилось с 2 г/т до I,4 г/т /30%/

б/ химводоочистки

- частота регенераций уменьшилась в I,2÷I,3 раза, расход щелочи уменьшился на 25%, расход кислоты на 5%.

в/ система умягчения воды:

- частота регенераций уменьшилась в среднем в 2 раза, расход поваренной соли снизился на 30%.

Ш. Производительность каждого вида фильтров составляет:

а/ конденсатоочистки:

до замены ионитов - 250000 м3

после замены - 400000 м3

б/ химводоочистки:

- НI ступени: до - 3000 м3

после - 5000 м3

- А I ступени: до - 7000 м3

после - 8000÷I0000 м3

- Н II ступени: до 5000 м3

после 20000 м3

- А II ступени: до - 9000 м3

после - I0000 м3

- фильтр смешанного действия:

до - 50000м3

после - 75000 м3

IУ. С использованием новых смол произошло уменьшение количества сбрасываемых /дренажных/ вод на 25% / с 500000 м3/год до 375000/

У. С вводом новых смол количество потерянного конденсата на станции не изменилось, но с улучшением качества использованных вод не наблюдается рост отложений на поверхностях нагрева, тем самым нет необходимости в проведении кислотных промывок основного ободудования станции.

Исходя из предварительных данных эксплуатации ионитов на Киевской ТЭЦ-5 наибольший эффект был достигнут в системе умягчения воды.

Д и р е к т о р С.Д.Сердюк

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APPENDIX L

BOILER ACID BLOWDOWN COST SAVINGS

Prior to USAID supplying resin for Kiev 5, the plant performed boiler acid blowdowns at least once a year on each of the four (4) unit boilers at a cost of approximately $15,000 plus the cost of processing the boiler acid blowdown water. Additionally, to perform a boiler acid blowdown takes three (3) days per boiler at a cost of losing approximately $500,000 of electrical generation which they would have to purchase from the grid. To reduce this cost the plant would schedule the cleaning over a weekend to reduce the loss of revenue by two-thirds to approximately $166,000 per boiler.

The four (4) peaker boilers, which are in the district heating water system, also needed a boiler acid blowdown once a year at a cost of approximately $10,000 each plus the cost of processing the boiler acid blowdown water. The peaker boilers only supply heat, therefore, there is no loss of electrical generation during the boiler acid blowdown.

Therefore

4 unit boilers x $15,000 per boiler	=	$ 60,000
4 unit boilers x $166,000 per boiler	=	$664,000
4 peaker boilers x $10,000	=	$ 40,000
TOTAL SAVINGS (per year)		$764,000

APPENDIX M

COST BENEFIT FROM DECREASED CHEMICAL USAGE

1. Acid (H_2SO_4) reduction of 10% year

150 ton/yr x 10% x $200/ton	=	$3000

2. Caustic (NaOH) reduction of 25% year

150 ton/yr x 25% x $400/ton	=	$15,000

3. Salt (NaCl) reduction of 30% year

1200 ton/yr x 30% x $50/ton	=	$18,000

4. Acid (HCl) reduction (boiler acid blowdown) 100%/yr *

– Unit 1 (2)	40 ton/yr x 2 units x $200/ton	=	$16,000
– Unit 3 (4)	60 ton/yr x 2 units x $200/ton	=	$24,000
– peaker boilers 1 (2,3,4)	40 ton/yr x 4 boilers x $200/ton	=	$32,000

5. Total reduction in chemical costs $108,000

* Since the new ion exchange resin has been installed no boiler acid blowdowns have occurred in 1995, 1996 and none are scheduled for 1997 for both the power plant boilers (4) and the peaker boilers (4). Prior to the new resin being installed each boiler was acid blowdown yearly. Appendix L

APPENDIX N

REDUCTION IN THE AMOUNT OF MAZUT USAGE

Kiev-5 uses 1010 tons/day of mazut when all four (4) units are at 100% capacity. Knowing that increased boiler water quality prevents scale buildup plant thermal efficiency must increase. Assuming that the increased efficiency is 0.1% the following benefits are achieved:

$$1010 \text{ tons/day} \times 2200 \text{ lbs/ton} \times \frac{1 \text{ gal}}{8.46 \text{ lbs}} = 262{,}647 \text{ gal/day}$$

$$262{,}647 \text{ gal/day} \times 0.1\% \times 365 \text{ day/yr} = 95{,}866 \text{ gal/yr or } 368 \text{ tons/yr}$$

Total Savings

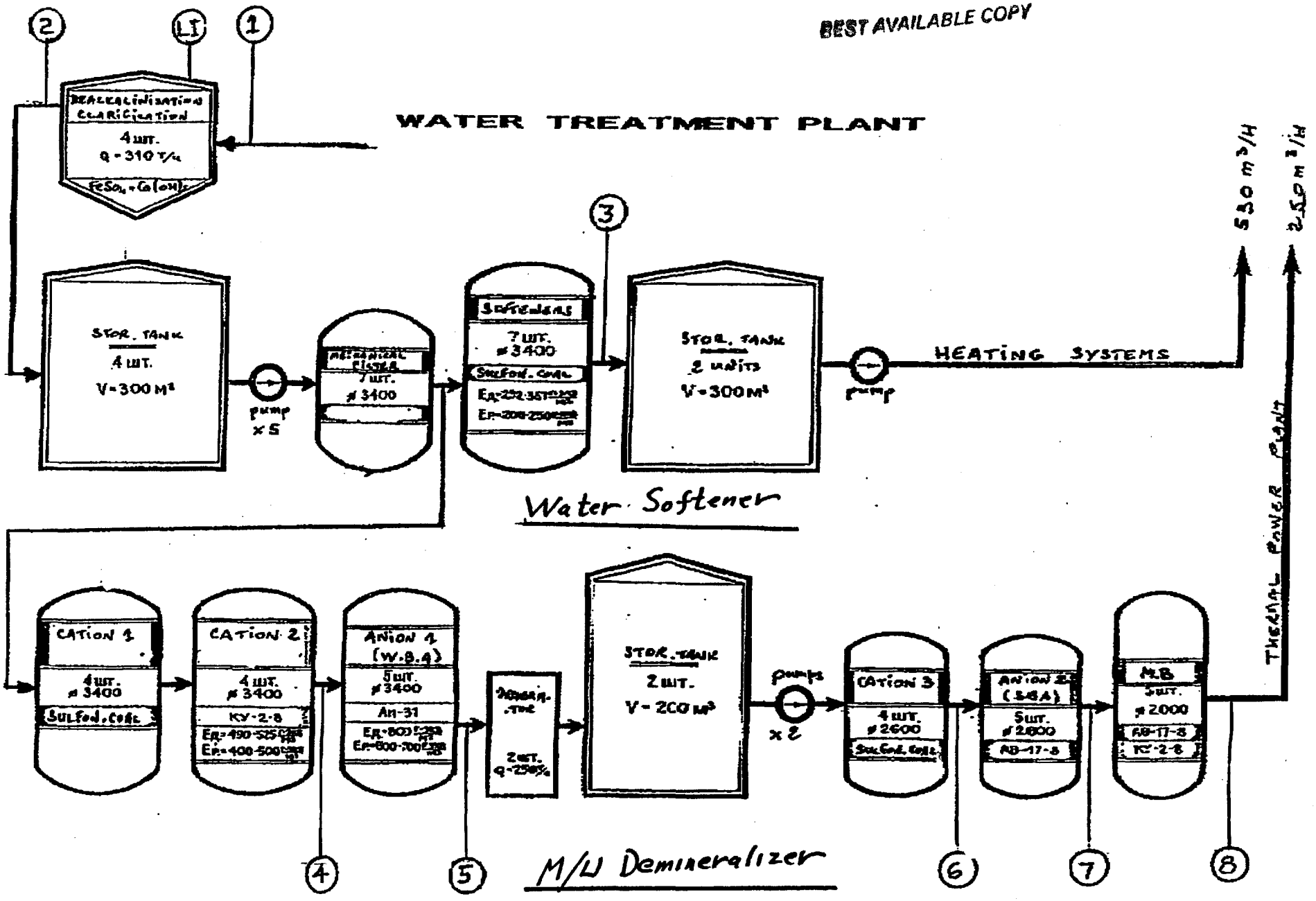
368 tons/yr x $91.38/ton = $33,627

APPENDIX O

TOTAL ANNUAL COST BENEFITS

1.	Reduction in chemical costs (Appendix M)	$108,000
2.	Savings due to not performing boiler acid blowdowns (Appendix L)	$764,000
3.	Reduction in mazut usage (Appendix N)	$33,627
4.	Total annual savings	$905,627

BEST AVAILABLE COPY



APPENDIX P