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ASSISTANCE IN CONSTRUCTION OF PRE-FABRICATED WOODEN HOUSING

SI/BHU/87/801/11-54

BHUTAN

Technical report: Assessment of the boiler plant at the Gedu Wood Manufacturing Corporation*

Prepared for the Government of Bhutan
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of M. Wettemann, boiler expert

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United Nations Industrial Development Organization
Vienna

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* This document has not been edited.

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1) INTRODUCTION

As part of its technical assistance programme to Bhutan the United Nations Development Programme has financed, and UNIDO has executed, a project that included, inter alia, assistance to the Gedu Wood Manufacturing Corporation (GWMC) in the field of maintenance of its boiler and the training of their operators. To that effect, Mr. Manfred Wettemann a Boiler Technician, undertook a four week mission to Gedu (Bhutan) from 25th May to 21st June 1989.

EXPERT SERVICE

As the boiler plant has been operated for 3 years and the operators have never been yet trained in its proper operation and maintenance it was decided to provide an expert in boiler maintenance to assess the condition of the boiler, train operators and draw up a preventive maintenance programme.

This technical service (called mission) was split in two parts.

The tasks of the first part of the mission were:

- to bring the boiler plant in proper operation
- to execute the necessary repairs and maintenance works
- to train the operator for basic operation
- to solve the water problem (treatment and dosing)
- to list-up the required spare parts

2) GENERAL INFORMATION

In the Gedu-Wood Complex a wood fired steam boiler plant generates and supplies the required saturated steam for the following consumers:

- 3 veneer dryers
- 1 hot press
- 1 blockboard press
- steam vats
- 3 kiln dryers

The production works in the following shifts:

- plywood factory: 1st shift: 07.00 - 11.00/12.00 - 16.00
  2nd shift: 16.00 - 20.00/20.45 - 24.30
- sawmill: 2 shifts as plywood factory
- joinery: only 1st shift: 07.00 - 11.00/12.00 - 16.00

- boiler plant:
  main load: 07.00 - 11.00/12.00 - 20.00/20.45 - 24.30
  low load: 11.00 - 12.00, 20.00 - 20.45, 24.30 - 07.00

It works as a closed system, i.e. condensate is pumped back to condensate collecting tank and feed tank. There are losses only as evaporated steam. (approx. 15 %).

The missing water is replaced by treated raw water (make-up water).

The wood waste of the production (sawmill, joinery, plywood and blockboard factory) is used as fuel for the steam boiler.

Refer to the photos 1 and 2 of Annex 12.

TECHNICAL DATA OF THE PLANT

1.0 Fuel Storage and Transport:

Wet material:
1 silo for hogged wood waste: 160 m3 net
1 discharge screw: min 3.6 m3/h
1 chain conveyor
1 double flap valve
1 fuel spreader
The wet material is spread onto the inclined grate.
The fuel passes the drying, the gasification and the burning section

Dry material:
1 silo for chips and dust: 160 m3 net
1 discharge miller: min 1.0 m3/h
1 blow-in fan
1 jet nozzle
The dry material is blown into the fire chamber where it burns out while flying.

2.0 Steam Boiler:

Make:	Gebrüder Weiss
Manufacturer's No.	11034
Year of Manufacture	1985
Permitted steam generation	7,500 kg/hr
Permitted operating pressure	20 bar
Normal operating pressure	10 - 12 bar
Feed water temperature	102 - 104 oC

Fuel: wet material: chopped shavings, sawdust and chips
dry material: sawdust, chips and dust

Boiler type: 3-pass shell boiler with drum type steam space with cooling screen above the furnace (water tubes)

Furnace type: inclined step grate with flat burn-out grate and cooled by primary and secondary combustion air

3.0 Water Treatment Plant:

Raw water quality: according to laboratory analysis:
total hardness: 0.16 mval/l = 0.45 degree dH 1)
m-value: 0.23 mval/l 1)
silicate: 8.50 mg/l
phosphate: 4.42 mg/l

3.1 Chemical treatment by:

1 mixed bed ion exchanger
capacity: 33 val
regeneration by: caustic soda and hydrochloric acid

1 chemical dosing
capacity: 0 - 14 l/h
chemicals: trisodium phosphate (rest hardness + pH-value)
sodium sulphite (rest oxygen)

3.2 Physical treatment by:

1 low-pressure degasifier
1 feed water storage tank: 7,500 l

heating steam pressure: 0.2 bar (operating pressure)
degasifaction temperature: 105 oC

4.0 Water Feed Devices:

1 Electrical driven feed water pump
for normal operation
capacity: 9.5 m3/h
head: 24 bar
power: 18.5 kW
speed: 2920 rpm

1 Diesel engine driven feed pump
for emergency operation (power failure)
same technical data as the electrical driven feed pump

1/ Definition from a chemistry text book.

5.0 Condensate Collecting System:

1 Condensate tank (in boiler house)
capacity: 5 m3

2 Condensate pumps (1 stand-by)
capacity: 10 m3/h
pressure: 3 bar
power: 3 kW
speed: 2900 rpm

1 condensate tank (at kiln dryers)
with sump pump
capacity: 1 m3

1) The measuring units of the concentration of chemical solutions are:
Mol in mol/kg or mol/l
1 mol = molecular mass of the respective chemical compounds in gramme (g)
Val in val/kg or val/l
1 val = 1 equivalence = 1 mol : valence
further:
Gramme in g/kg or g/l: mg/kg, mg/l, 1 ppm = 1 mg/kg

Hardness: 1 mval/l = 2.8 degree dH = 3.51 degr eH
1 degree dH = 1,79 degr eH = 1,25 degr fH

3) CONDITION OF EXISTING PLANT (boiler inspection)
Checks and findings

The boiler plant has been operating for three years. The first boiler inspection was carried out by the floor engineer Mr. Wensley on 2nd June 1988. His inspection report of 07.06.88 is kept in GWMC.

Exactly one year later the 2nd boiler inspection was carried out under the direction of the UNIDO boiler expert.

The whole boiler plant was shut-down for 5 days.

After the cooling down of the furnace ard the boiler drum the following findings were made:

Furnace inspection:

The refractory walls were worn normally: only two cracks were found and immediately repaired.

On the right grate side the sliding plates were totally burned out and bent up so that the natural sliding of the fuel was stopped. The damaged plates were replaced by self-made steel plates which after one week again were bent and had to be replaced by used but not too badly worn cast plates. The problem was that there were not enough spare plates. (see photos 3 to 9 in Annex 12).

The step bars and the flat bars were in good condition.

On the walls there were a lot of flue gas ash which could be easily removed.

Drum inspection:

A lot of red sludge and scale covered the inserts of the drum. Particularly the upper part of the smoke tube were covered by thick scales. One big sludge block was stopping a junction point of the cooling section. (see photos 10 and 11 in Annex 12)

The loose scales and the sludge were removed very carefully. The covering in the cooling pipes could not be checked. The scale formed up to 2 mm thick plates. The first assumption, that the scales consist of silicate compounds which are very dangerous for the pipes could not be confirmed. As the analyses of the collected samples showed the sludge and the scales consist of the same elements: Iron and calcium phosphate compounds, no silicate and carbon.

The remaining part of scales particularly in the cooling pipes will be removed in future during operation by dosing of trisodium phosphate surplus (1 kg/day for minimum content of 20 mg/l boiler water) and higher blow-down rate.

The rusty surface of some parts indicates that too much oxygen gets into the boiler (during stand-still and operation as residual oxygen). This will be prevented in future by holding the degasifier under steam pressure and by dosing of sodium sulphite.

General Condition:

The boiler plant and the water treatment plant are generally in a good condition and the above mentioned problems can be solved in future.

Design:

The existing plant is correctly designed and suited for the actual local conditions and requirements:
- inclined grate for wet fuel
- saturated steam boiler as 3-pass boiler with cooling screen
- water treatment plant as mixed bed exchanger (silicate)

Operation:

The following instruments and control and regulation equipment had not been set correctly before the expert's arrival in Gedu:

- low level cut-out
- level control
- combustion air dampers
- fuel spreading
- steam pressure control
- uncorrect regeneration
- correct dosing
- stable degasifier steam pressure

The operators did not know how to set the equipment correctly. The main problem was the underpressure control of the combustion chamber. It was not working properly because:
- the air dampers were not set correctly (too big opening angle). the correct setting for full load is shown in photo 13 (Annex 12)
- the existing flue gas channels from the old Indian boilers to the chimney have not been closed (short circuit).

There were often an overheating of the fuel feeding equipment (spreader and double flap valve) and a back fire up to the chain conveyor. (see photo 12 in Annex 12).

The present boiler load is maximum 4 t/h saturated steam according to the calculation and measurements during its operation (condensate return flow, make-up water supply and fuel feeding).

4) REPAIRS AND MAINTENANCE EXECUTED

During the boiler shut down a lot of repairs and maintenance were carried out. These were reported by the boiler foreman and kept in GWMC.

Main works:

- grate repairs: the burnt sliding plates on the left side of the grate were replaced by steel plates
- two safety valves were replaced by a new one
- a new fuel spreader was made of steel
- a new level switch above the double flaps valve was installed
- a new water level indicator glass was installed
- the low level cut out electrode was shortened to the correct length
- electrical feed pump: worn packing material was replaced
- all strainers checked and cleaned
- cleaning of all smoke tubes and collecting pipes
- closing of the flue gas channels of the old Indian boilers by a brick wall
- additional installation: raw water by-pass line
  pressure indicator between reducing valves for degasifier
  blow-down line for level indicator at condensate tank

5) SETTINGS OF SAFETY AND CONTROL EQUIPMENT

The 2 safety valves could not hold the steam pressure above 12 bar. This was due to the broken pressure springs. There was only one spare safety valve, it was installed instead of the 2 old ones. The second one has to be installed immediately after receipt of the new spare spring.

The low level cut out electrode was shortened to the correct length and the switching-off of the plant was checked by setting down of the water level to the minimum level mark (N-W) 1).

The underpressure control of the furnace was the main problem of the operation which was solved mainly by correct setting of the combustion air dampers. The air dampers had been opened too much so that the induced draft fan could not suck enough flue gas to get a negative pressure in the furnace.

The normal water level of the boiler has also been set too low (at the N-W mark). The level was set correctly 50 mm above the N-W mark.

The steam pressure was set to 10 - 12 bar according to the requirements of the heat consumers.

The heating steam system of the degasifier was set to a proper operating condition without blowing off by the safety valve: two reducing valves and the flow rates of the condensate and make-up water had to be adjusted correctly to get a stable operating pressure (0.1-0.25 bar). The safety valve opens at 0.32 bar.

The water level on the condensate tank and the flow rate were set for better continuous operation.

The combustion air dampers (primary and secondary) were set according to the combustion temperature and the CO2-content in the flue gas.

All the above mentioned settings are established in the setting list given in Annex 8.

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1) N-W stands for lowest water level in German (Niedrigst-Wasser).

6) FUEL SUPPLY AND FEEDING

The size of the chips produced is too big. The wet wood waste is badly hogged.

The main reason for this is that the chipper knives are damaged very often by iron and steel parts which pass the chipper.

The chip size is sometimes up to 200 mm. Therefore the material is bulky and causes stops in the double flap valve.

A metal detector before the chipper would be the best investment but it is very costly.

The charging of the chips to the silo centre was improved by a guide plate on the top of the silo: better distribution and discharging (homogeneous material)

The electrical and hydraulic settings of the double flap valve and the fuel spreader were set correcly so that the grate will be covered symmetrically which is very important for correct combustion and the protection of the grate against radiant heat.

The following fuel rates were measured:
- chips in position A: 17 kg/min = 1020 kg/h (283 kg/m3)
- chips in position B: 34 kg/min = 2040 kg/h
- dust in position 2 : 4.5 kg/min = 270 kg/h (180 kg/m3)

If in future the hogging of the chips will not be improved the space between the flaps of the double flap valve will be too small.

An improvement is recommended in chapter 11.

7) WATER TREATMENT AND CHEMICAL DOSING

The required make-up water for the boiler plant has never been treated since its commissioning 3 years ago. Pure raw water has been used with its natural content of silicate and hardness.

Silicate can be very dangerous for the boiler as scale because its heat transfer is very, low and for this reason, the covered pipes can be overheated and burst under high pressure. Therefore it is very important to prevent any formation of silicate scales.

The silicate in the raw water can be totally be removed by the existing mixed bed ion exchanger. Any residual silicate in the boiler water can be bound by phosphate which has to be dosed into the feed water. Trisodium phosphate will be used as chemical dosing agent which bind the residual hardness, silicate and increases the pH-value of the water.

The capacity of the mixed bed exchanger is about 33 val which means that approximately 150 m3 raw water can be treated before the exchanger material is exhausted and must be regenerated. The cation resin is regenerated by hydro chloride (HCl) and the anion resin by caustic soda (NaOH). The regeneration has to be performed approximately every two weeks.

As the regeneration has never been done since the commissioning the mixed bed exchanger was use as a filter and a lot of sludge has been collected in the last three years.

During the mission two effective regenerations were performed:

It took a lot of time for cleaning, removal of stops and leakages in the piping to get the plant in proper operation. The suction jets for the chemicals were designed too small, therefore the instruction manual has been revised.

Most of the problems could be solved by cleaning the pipes and changing the procedure (smaller flow rates and longer reaction time). The pollution of the resin by sludge could not be removed in the short time available.

A rough examination of a small sample of the mixed resin showed that the material was not damaged but should be cleaned outside the vessel. This can be done during the expert's second mission to Bhutan.

The water treatment plant was working well after this maintenance. The regeneration can be carried out by the operator (foreman) every two weeks which is not too much work and too complicated.

The result of all this is the best water quality: totally free of hardness and silicate which is a basic requirement to get the boiler free of scales, which means a long life of the boiler plant and less interruptions of production.

The thermal degasifying was working well; only the steam pressure had to be set more stable.

The degasifier has the function to remove the oxygen in the feed water. But there is still a dangerous residual oxygen content which has to be bound. Oxygen is the reason of all corrosion in a boiler plant and the whole steam and condensate piping system. Therefore it is very important to eliminate all oxygen content in the feed water.

An economical way to bind the residual oxygen is chemical binding by a dosing agent. There are 2 main chemicals which bind oxygen: hydrazine (N_2H_4) and sodium sulphite (Na_2SO_3). At the time of commissioning sodium sulphite was use. But since more than two years no chemical agent was dosed for oxygen binding. The result can be seen in the boiler drum and in the steam and condensate piping system. Everywhere a lot of oxygen corrosion can be found.

It is very important to dose sodium sulphite for residual oxygen binding and trisodium phosphate for residual hardness and increasing the pH-value. Iron corrodes less if the water it is in contact with has a high pH-value (above 8.5).

For removal of the scales which are still existing in the boiler the dosing rate of the phosphate has to be kept higher than is normally necessary.

The exact dosing rates for the chemicals, the revised instructions for the regeneration and operation of the water treatment plant were recorded in a check list given in Annex 6.

8) TRAINING FOR PROPER OPERATION

The plant runs 24 hours a day (3 shifts) and will be monitored by one operator per shift. In the day shift the foreman and one mechanic are also present.

The foreman is the only man who can speak, read and write the English language.

Therefore he was the only person who received professional training.

The documentation in the plant is not complete: Some important operating/maintenance instruction manuals for the hydraulic unit, centrifugal pumps and water treatment plant are missing. These have to be required and collected from the manufacturer and mailed or handed over personally in the next mission. This was however not a real problem for the correct operation and maintenance.

The responsible foreman was never correctly and sufficient trained during and after the commissioning.

Since the commissioning the operation of the boiler has not been properly done:

- The underpressure control has not worked automatically.
- The steam pressure was controlled by manual switching on/off of the fuel infeed.
- The water level control was set too low.
- The condensate level was controlled manually.
- The main operating work: the fire control for proper combustion conditions have never been done correctly (symmetrically covering of the grate by the fuel, primary and secondary combustion air setting)

During the mission especially the foreman was trained how to operate, to set and to service the plant. A number of instructions were recorded: see the attached check lists (chapter 12).

During the daily round the foreman was advised orally on the correct operation, particularly the correct fire adjustment for partial and full load. He was taught the correct blowing-down of the boiler water, blowing-through of the water level indicators and the recording of operation data.

The operator was advised on water testing and changing of the dosing rate for correct water conditions. The required test kits (listed in chapter 10) were brought by the expert and left at the GWMC.

The regeneration of the mixed bed filter was performed twice with recording of additional instructions to those of the manufacturer. (Annex 10)

9) SPARE PARTS

There are not enough spare parts in store.

The plant has been running since 3 years and it is time now to provide some more spare parts for the future. The boiler plant is the heart of the production and if the plant does not work properly the production also will not work properly.

There are parts which are very important if they are defective the whole plant is in danger and out of control. There are parts (control devices) whose function can be taken over by parts which are manually operated but only for a short time. Further there are very useful parts which are not expensive but should be always in store.

In the spare part lists given in Annex 1 contain all important wear and tear parts of the

- fuel transport equipment
- boiler combustion section
- boiler pressure section
- feed tank and feed pumps
- condensate tank and pumps
- water treatment and dosing plant
- piping system
- electrical control panel

for
- immediate need
- 1 year operation and
- 5 years operation

The make and type and the number of the installed parts are stated in the lists.

The responsible persons of the GWMC (foreman, floor engineer and manager) have to find out the source of supply and where they can get the parts from. (locally made, purchased in India or overseas)

Recommendation:

All the spare parts for the boiler plant shall be stored in a separate cabin in the boiler house and sorted according to the above listed sections.

10) TOOLS, OPERATING FACILITIES, ADDITIONAL INSTRUMENTS

The existing tool box in the boiler house does not contain the correct and complete range of necessary tools for immediate action. Sometimes it took too long to get the right size of spanners for immediate repair during operation. This has to be improved.

The following chemicals will be used in the plant:

- Hydrochloric acid HCl for regeneration of cation exchanger resin
- Caustic soda NaOH for regeneration of anion exchanger resin
- trisodium phosphate for binding of residual hardness and increasing of pH-value of the feed and boiler water
- sodium sulphite for binding of residual oxygen in the feed water

The regeneration chemicals in store HCl and NaOH are sufficient for operating for the next 10 years.

Trisodium phosphate (Na_3PO_4) is only available for the next 5 months and Sodium sulphite (Na_2SO_3) was not available in the plant and has to be provided immediately. Both chemicals can be purchased in India.

The consumption of the chemicals is as follows:

- HCl 31/33% : 9 ltr/2 weeks = 225 ltr/yr (in store: 2.400 ltr)
- NaOH 45% : 8 ltr/2 weeks = 200 ltr/yr (in store: 2.200 ltr)
- Na_3PO_4 : (July + Aug): 25 kg/month (in store: 120 kg)
  (later): 0.5 kg/day = 12.5 kg/month = 150 kg/yr
- Na_2SO_3 : 0.1 kg/day = 2.5 kg/month = 30 kg/yr

Water Test Kits:

In order to make the necessary water analyses the following test kits are minimal required:
- pH-value test kit (feed and boiler water)
- phosphate test kit (boiler water)
- silicate test kit (make-up water)
- sulphite test kit (feed water)

The first 3 test kits were brought and left by the expert. The sulphite test kit was sent by him by air parcel end of July.

The test kits needed for the next 3-4 months are available (depending on the consumption of the reagents and how often the water will be tested)

Additional water test instruments and reagents were handed over:

- Density meter for boiler water
- Thermometer 0 - 100 oC
- Erlenmeyer flask 200 ml
- Measuring glass
- Automatic brown burette (for titration)
- Filter papers
- 1 ltr test hydrochloric acid 0.1 mol/l (p/m-value)
- Phenolphalein solution (p-value)
- Methyl orange solution (m-value)
- Oxygen test kit
- Residual hardness test kit

1 chemical filling pump (hand-pump) has to be provided:
(filling-up of the storage tank of the regeneration agents)

11) RECOMMENDATIONS

Additional installations in future

1) Water treatment plant:

1 flow meter (counter) DN 20 in feed pipe:
(for checking of the operation and recording of the consumption)

2) Dosing plant.

1 Manual/Automatic-switch in the panel:
(for start-up phase and normal operation)

3) Feed pump:

2 stop valves DN 15 in the minimum flow pipe
(for repairs and maintenance)

4) Condensate tank:

2 stop valves DN 20 PN 10 at the level indicator (maintenance)
1 flow meter (counter) DN 50 between pumps and feed tank
(for checking of the operation and recording of the consum.)

5) Boiler:

1 flow meter (counter) DN 50 between feed pumps and boiler
(for checking of the operation and recording of the consum.)

6) Fuel supply

2 operating-hour counters for chips and dust
(for recording of the consumption and its balancing)

Spare parts

The spare parts listed for immediate need should be bought at once.

The spare parts listed for one year operation should be provided as soon as possible.

General Training

The boiler foreman Leki Dorji should be sent for a general training for boiler operation to Canada or the United Kingdom. The special training will be provided locally during the next mission.

Changing of the installation

One of the main problems of the plant are the fuel stops in the double flap valve and on the inclined grate:

The stops in the double flap valve can be remedied by enlarging the cross section of the duct (in the direction to the silo).

The stops of the fuel slides on the change of the refractory grate and step grate will be improved by providing of a fire concrete beam instead of the special slide plates for which no spares exist.

12) CHECK LISTS

The following lists were compiled and handed over to the operator of the boiler plant:

- check list for operating data (Annex 2)
- check list for start-up of the boiler plant (Annex 3)
- check list for operation (daily checks) (Annex 4)
- check list for shut-down of the boiler plant (Annex 5)
- check list for chemical dosing (Annex 6)
- check list for weekly checks (Annex 7)
- setting list (Annex 8)
- maintenance list (Annex 9)
- check list for regeneration of water treatment plant (Annex 10)
- reference list for monthly boiler plant report (Annex 11)

13) FURTHER ACTION (2nd phase of mission)

The task of the first phase of the mission was:

- to bring the boiler plant to a proper operation
- to execute the necessary repairs and maintenance works
- to train the operator on its basic operation
- to solve the water problem (treatment and dosing)
- to list the required spare parts

The task of the second phase of the mission should be:

- further operating training (checkings and reporting)
- improvements on the grate (concrete beam)
- improvements of fuel discharging and feeding
- checking and cleaning of the exchanger resin (water treatment)
- checking of boiler water and scale formation
- additional installations (listed in chapter 11)
- provision and storage of spare parts
- improvements of the steam and condensate piping system
- completion of the operating and maintenance instruction manual (of the manufacturers'

It is anticipated that the second phase of the mission will take place in November 1989.

ANNEX 1

GEDU-WOOD MANUFACTURING CORPORATION/BHUTAN - BOILER PLANT

LIST OF SPARE PARTS

	mfr/type	inst.	immed.	1 y	5 y 1)
1.0 FUEL Transport Equipment					
1.1 Chips discharge equipment (Screw-type)					
refer to WEISS Spare Parts Catalogue of AS 2/55/RS/7,5MI315 and PIV-list EL-51.001 GB (enclosed in operating + maintenance manual)					
- freewheel clutch	Weiss 315165	1	1	-	-
- anti reversing lock	Weiss 315164	1	1	-	-
1.2 Dust discharge equipment (Miller-type)					
refer to WEISS Spare Parts Catalogue of AF 8/55/R.G.5.5.MI (enclosed in operating + maintenance manual)					
2.0 BOILER - Combustion Section					
2.1 Fuel feeding					
- hydraulic cylinder for flaps	Vickers System 22728/1 HRZ-CX	2	-	1	1
- hydraulic cylinder for spreader	Vickers System 22728/2 HRZ-CX	1	-	-	1
- repair kit			3	3	-
- bearings for flaps		6	-	-	2
- level switch	E+H/FTM 230	1	-	-	1

1) mfr = manufacturer
inst. = installed
immed. = immediate need
1 y = for 1 year operation
5 y = for 5 years operation

	mfr/type	inst.	immed.	1 y	5 y 1)
2.2 Hydraulic unit	GL-Hydraulik Ser.No. 5007	1	-	-	-
consists of:					
- hydraulic pump	11 l/min	1	-	-	?
- electric motor	2.2 kW/1450 rpm	1	-	-	1
- filter	Mann/W962	1	-	1	-
- solenoid valve	MS43P06CF31A1D3	3	-	-	2
- solenoid valve	MS42P06AF01A1D3	1	-	-	1
- coil for valve	- " -	7	-	3	2
- manometer	Wika/0-160/63	4	-	1	1
2.3 Furnace (Combustion chamber)					
- refractory material	clay		25 kg		
	cement		25 kg		
	castable refractory			25 kg	
- refractory brick (ash door protection)	300x400x120 mm	1	-	-	1
- adapter fire bars	Weiss CSL9198	20	) will be replaced		
- sliding plates	Weiss CSL9197	8	) by fire concrete		
- step grate bars	Weiss 1000 mm	20	-	8	12
- step grate bars	Weiss 800 mm	40	-	16	24
- support bars	Weiss 80x980mm	6	-	-	6
- rear support bar	Weiss 900 mm	2	-	-	2
- centre support bar	Weiss 900 mm	2	-	-	2
- fire bar	Weiss 600 mm	48	-	-	48
- side fire bar	Weiss 600 mm	6	-	-	6
- side angle bar	Weiss 600 mm	6	-	-	6
- fire watch glass	Weiss	4	-	2	2
2.4 Combustion air fan					
- bearings	ball type	2	-	-	2
- V-belts		3	-	3	-
- electric motor	7.5 kW/2910	1	-	-	1
2.5 Dust fan					
- bearings	ball type	2	-	-	2
- V-belts		3	-	3	-
- electric motor	7.5 kW/2860	1	-	-	1

	mfr/type	inst.	immed.	1 y	5 y 1)
2.6 ID-fan					
- bearings	antifrig.	2	-	2	-
- V-belts		4	-	4	-
- flow monitor	DWF U/B	1	-	1	-
- electric motor	45 kW/1465	1	-	-	1
2.7 Control equipment					
- servo motor:	Aris/WAN 6	1	in store		
- combustion thermometer	1xPtRh-Pt	1	in store		
3.0 BOILER - Pressure Section					
- safety valve	Leser/4412.4524 DN 32 PN 40	2	-	-	1
- safety valve spring	- " -	2	1	1	-
- level indicator complete with valves	DN20PN40-340 mm	2	-	-	1
- level indicater glass with seal rings and gasket	Maxos/DIN 7081 340 mm	2	1	1	-
- steam manometer	WIKA/0-25/160	1	in store		
- pressure controller	Sauter/DFC17B	2	-	1	-
- pressure limiter	Sauter/DFC 27	1	-	-	1
- level electrode	Gestra/ER16-1	1	-	1	-
- level electrode	Gestra/ER96-1	1	-	1	-
- servomotor for contol valve	RTK/WR3115095	1	-	1	-
- continuous blow-down valve	Gestra/BA 26K DN 20 PN 40	1	-	-	1
- intermittent blow-down valve	Schulte DN 40 PN 40	1	-	1	-
4.0 Feed Water Pumps	DIA/HKM1.5/1.2	2	-	-	-
- packing material	part no 461	2	2	2	-
- shaft sleeves	part no 524.2	2	2	2	-
- ball bearing	part no 321	2	-	2	-
- set gaskets	part no 412	1	-	1	-
- coupling		1	-	-	1

	mfr/type	inst.	immed.	1 y	5 y 1)
- autom. non return valve	Schröter/ DN32PN40	2	spare parts in store		
- electric motor	18.5 kW/2965	1	-	-	1
- Diesel motor:	Hatz/2M40L	1	-	-	-
- maintenance set	Hatz 00987102	-	-	1	-
- emergency set	Hatz 00987202	-	-	1	-
- gasket set for cylinder head	Hatz 00992200	-	-	1	-
5.0 Feed Water Tank					
- level indicator glass with seal rings	12 x 1.24 m	1	1	-	1
- exhaust steam valve	R1/2"	1	-	1	1
- level switch	SO1D-F04.1	1	-	-	1
- temperaturer controller	Sarco/412T3	1	-	-	1
- reducing valve	Sarco/DP17S DN25 PN25	1	-	-	1
- pressure spring (yellow)	- " -	1	-	1	-
6.0 Condensate Pumps	DIA/SN 32-160	2	(1 stand-by)		
- packing material	part no 46.1	1	-	1	-
- shaft sleeves	part no 52	1	-	1	-
- set of seal rings	part no 40...	1	-	1	-
- ball bearings	part no 32.1	2	-	2	-
- felt ring	part no 50.7	2	-	2	-
- electric motor	3 kW/2895	1	(1 stand-by)		
7.0 Condensate Tank					
- water level indicat.	Igema/NA7-45	1	in store		
- magnetic switch	Igema/M410	2	1	1	-
8.0 Water Treatment Plant	Hager + Elsässer				
- circulating pump	Grundfos/UP25-45N	1	in store		
- air compressor	Alof/DT3.6	1	-	-	1
- flow meter	GEMÜ/07/17	1	in store		

	mfr/type	inst.	immed.	1 y	5 y 1)
- conductivity meter with electrode	E+H/LzW1 XG 0.1	1	-	1	-
- deaerator	R3/4"	1	-	-	1
- throttle valve	DN 20	4	-	-	2
- throttle valve	DN 15	12	-	-	4
- medium membrane for	DN 20	4	-	2	-
- medium membrane for	DN 15	12	-	4	-
- ball valve	DN 15	11	-	-	3
- solenoid valve	DN 25	1	-	1	-
- o-ring sets for	DN 15/20	12/4	-	5/2	-
- ball valve with grate indicator	DN 15	2	-	-	1
- PVC-sockets	DN 15/20	for repair	-	10/10	-
- PVC-pipe	DN 15/20	for repair	-	2/2 m	-
- PVC-bends	DN 15/20	for repair	-	10/10	-
- PVC-unions	DN 15/20	for repair	-	5/5	-
- PVC-glue		for repair	-	1 tin	
9.0 Dosing Plant					
- membrane pump	Alldos/M241-12	1	-	1	-
- electric motor	Siemens/1LP3053	1	-	1	-
- pressure relief valve	V85 PVC/HF1 DN5 9 bar	1	-	1	-
10. Piping System					
- stop valves for condensate tank	DN 20 PN 10	-	2	-	-
- stop valves for feed pumps	DN 15 PN 40	-	2	-	-
- stop valves for boiler blow down	DN 40 PN 25/40	5	-	2	-
- stop valves	DN 32 PN 25/40	4	-	-	1
- reducing valve springs	yellow		-	1	-
	blow		-	2	-
	red		-	1	-
- manometer valves	1/2 "		-	3	-
- valve packing material	DN 20 - 150		-	1 set	-
- flange bolts 4 D	DN 20 - 150		-	1 set	-

11. Electrical and Control Equipment
(installed in control panel)

	mfr/type	inst.	immed.	1 y	5 y 1)
- low level cutout relay	Gestra NRS1-3	1	-	-	1
- level control relay	Gestra NRR2-1	1	-	1	-
- temperature indicator	Jumo OR Bt-96	1	-	-	1
- ring balance controller	Rixen rix-o-tact	1	-	-	1
- presetting relay	Weiss 312901	1	-	-	1
- programmer 4.35K6	SchleicherKS5198	1	-	1	-
- timer	Schleicher				
1.30K10,4.36K7	Kl.0323/4, 0323/5	2	-	1	-
- stand still monitor	ifm A 300/AZ 33-B	1			
- time relays	Klöckner Möller				
	TPD 11 OIL R	6	-	1	1
	TPE 11 OIL R	6	-	1	1
- time relay 7.25K5	Dold A 1700	1	-	-	1
2.01K4, 7.01K4	Dold SZ 29	2	-	-	1
- control relays	Klöckner Möller				
	DIL R22/timer	11/10	-	-	2/2
	DIL R31/timer	6/1	-	-	1/1
	DIL R40/timer	6/2	-	-	1/1
- contactors	Klöckner Möller				
(2.01K1,K2,K3)	DIL 2M+11DIL M	3/3	-	-	1/1
	DIL OM/11DIL M	3/1	-	-	1/1
	DIL OOAM/	12/	-	-	2
	11DIL/11DLL M	4/3			1/1
	DIL OAM/	2/	-	-	1
	11DLL M/22DIL	1/1	-	-	1/1
- bi-metal relays	Klöckner Möller				
	Z00-0.4	2	-	-	1
	-4.0	1	-	-	1
	-1.0	1	-	-	1
	-6.0	1	-	-	1
	-10	3	-	-	1
	-16	4	-	-	2
	Z1-40 (24-40A)	1	-	-	1
	Z4-100 (70-100A)	1	-	-	1

	mfr/type	inst.	immed.	1 y	5 y 1)
- D-fuses for E27	2 A	7	-	-	3
-	4 A	4	-	-	2
-	10 A	5	-	-	2
-	16 A	3	-	-	1
-	20 A	6	-	-	3
- D-fuses for E33	35 A	12	-	-	3
- NH-fuse links	63 A	3	-	-	3
-	160 A	3	-	-	3
- main switch (0.30Q1)	Klöckner Möller N94-250	1	-	-	1
- control transformer (0.30 T1)	ismet CSTU 1000/2000VA Nr 596/31/5J	1	-	-	1
- switches	Kraus+Naimer/BG10				
- manual/automatic	A 212	4	-	-	2
- on/off	A 202	7	-	-	2
- +/-	D-F 643	2	-	-	1

1) mfr = manufacturer
inst. = installed
immed. = immediate need
1 y = for 1 year operation
5 y = for 5 years operation

ANNEX 2

CHECK LIST FOR OPERATING DATA

Steam pressure	bar	10 - 12
Load (pos.of contr.valve)	mm	5 - 10
Underpressure	mbar	0.6 - 1.2
Combustion temperature	oC	600 - 900
Flue gas temperature	oC	above 250
Fuel: chips/dust	-	chips
Feed tank level (mark)	%	above blue mark
Feed tank pressure	bar	0.2
Feed tank temperature	oC	100
Cond. tank temperature	oC	70 - 90
Cond. tank level (mark)	%	betw. the level switches
Make-up water supply	l/h	1000 - 1500
Pos. of chips disch.	A-E	A - B
Pos. of dust disch.	1-10	1 - 3
Blow-off	%	5

Water tests: (according to the instruction of the kits)

				day
Make-up water	conductivity	µS/cm	0.2	1
	SiO2	mg/l	0.3	3/2
	pH-value		5 - 8	7
Feed water	pH-value		7 - 9.5	1
	sulphite	mg/l	0.2 - 0.3	1
	conductivity	µS/cm	0.03	1
	resid. hardness	odH	0.02	7
Boiler water	pH-value		10 - 11	1
	phos-content	mg/l	10-20/5-10	1
	conductivity	µS/cm	below 50	1
	SiO2	mg/l	below 30	7
	resid. hardness	odH	0.1	7
	p-value	mval/l	1 - 5	3
	sulphite	mg/l	max. 20	7
Condensate	conductivity	µS/cm	0.3	7
	pH-value		7	7

p-value test:
1) fill the test glass to 100 ml mark
2) add 3 drops p-reagent (Phenolphtalein)
3) titration by 0.1 m HCl till red colour disappears

consumption of 0.1 m HCl in ml = p-value in mval/l

ANNEX 3

CHECK LIST FOR START-UP OF THE BOILER PLANT

COLD START-UP

After weekend:
Precondition: Condensate tank maximum full (on Saturday)
Feed water tank full (deaerated)
enough dry material (dust)

Start-up:

1 Close the make-up water supply with the ball valve.
2 Fill-up the boiler to low level cut-out
3 Switch off the feed pump
4 Put dry wood material on the burn-out grate
5 Close the combustion air dampers
6 Switch on the induced draft fan
7 Feed-in the chips by switching on/off the combustion air fan
8 After covering 30 % of the grate with chips make fire from the bottom (maybe without induced draft fan)
9 Open slowly the combustion air dampers according to the fire formation and temperature rise
10 Feed-in chips according to the fire formation
11 Blow-down (boiler water) according to maximum water level (150 mm above N-W mark)
12 Supply the first steam to feed tank
do not change the settings of the reducing valves
do not feed make-up water to feed tank till steam pressure is minimum 0.1 bar and water temperature is minimum 90 oC
Do not worry about the low level, use condensate
13 Supply steam to consumers (factory) from 3 bar onwards (very slowly)
14 Set-up fire for steam pressure up to 10-12 bar
please note that the grate should be covered by chips symmetrically
15 Air damper setting: normal load: upper 40 - 50 mm
lower 30 - 40 mm

WARM START (boiler and feed tank are still under steam pressure)

The above mentioned preconditions after week end are not necessary.
Points 1, 3, 11, and 12 are not relevant in this case.

ANNEX 4

CHECK LIST FOR OPERATION (daily checks)

1 Fire Control: the grate should be symmetrically covered by chips regulated by Relay 4.36-K7 and hydraulic speed

2 Combustion air dampers:

primary setting:	day load: upper:	40 - 50 mm
	lower:	30 - 40 mm
	night load: upper + lower:	20 - 30 mm
secondary setting:	burn-out grate:	pos. 2 - 3
	chamber air:	pos. 2 - 3

3 Check burn-out grate: maximum material height: 200 mm
ash removal at night shift

4 Fuel supply:

discharge screw:	position
chain conveyor:	symmetrical feeding
double flap valve:	clogging
fuel spreader:	symmetrical covering
hydraulic unit:	oil level + leakage

5 Underpressure control: 0.6 - 1.2 mbar
if induced draft fan stopped: 0.1 mbar
position of flue gas damper:
not fully open

6 Combustion air : if higher than 1000 oC the chamber air damper has to be opened by 1 step and if it is below 500 oC to be closed by 1 step

7 Boiler drum:

Steam pressure settings:	chips 11 - 12 bar
	dust 10 - 11 bar
Water level indicator:	normal: 50 mm above N-W mark
	cleaning by blowing-through

Proper operation of control valve: normal position: 5 - 10 mm

8 Blow-down valves: daily at 11.00 - 12.00 h
check water level during blowing-down

check leakages (hot pipe)
drum valve: 3 x 5 sec
other valves: 3 x 3 sec each

9 Condensate tank: check the water level:

The automatic switching on/off of the pumps to be checked often.
Sometimes there is a problem with the water movement in the tank and the automatic level control does not work.
Then operate manually for one charge.
discharge time: approximately 5 min
daily blow-through the level indicator (cleaning)

10 Feed water tank

water level: normal: at blue mark
daily blow-through (cleaning)

boiling pressure: normal: 0.2 bar
check vent valve
reducing valve setting:
only the 2nd one very slowly

after boiling: temperature: normal 100 oC
check whether the temperature regulator is fully in the pipe

11 Dosing tank

daily fill up by make-up water (treated water)
daily add:
trisodium phosphate: 1/0.5 kg
sodium sulphite: 100 g (according to the required sulphite content)
NaOH: according to the required pH-value (Annex 2)
set the flow rate: normal 35 %
according to daily filling of 70 - 90 l

12 Water treatment plant: feed pressure: 3.5-4.5 bar (raw water pump)
flow rate: normal: 1.000 - 1.500 l/h
max.: 1.800 l/h
min.: 400 l/h

13 Feed pump: check the packing leakage

14 Bearings: check the bearing temperature of:
- feed pumps)
- induced draft fan) max. 80 oC
- combustion fan)

ANNEX 5

CHECK-LIST FOR SHUT-DOWN OF THE BOILER PLANT

WEEKEND - SHUT-DOWN

1 The last shift shall store dry material for the next start-up.

2 Further more the last shift shall fill-up the condensate tank by setting higher the level switches (or manually).

3 At about 24.00 h, 30 minutes before factory closing, bring fire and steam pressure slowly down.

4 Switch off the fire when steam pressure is about at 5 bar and only low fire is on.

5 Close the main gate valve to the factory.

6 Close the main air dampers: leave only the lower damper a finger wide open.

7 Switch off the induced draft fan.

8 Switch off the feed pump.

9 Close to slightly open the steam valve before the reducing valves of the feed tank.

10 Close the ball valve of the water treatment plant.

11 Switch off the main switch.

12 Before leaving of the plant check whether the fire is out or very low.

ANNEX 6

CHECK-LIST FOR CHEMICAL DOSING

The following chemicals can be mixed with one another

1 Trisodium phosphate Na_3PO_4

for binding residual hardness (SiO_2), for removing the existing scales in the boiler and for increasing of the pH-value

for the 1st stage (July and August): 1 000 g / day
for the 2nd stage (after August): 500 g / day

the phosphate-content (P_2O_5) in the boiler water should be:

for the 1st stage (July and August): 10 - 20 mg/l
for the 2nd stage (after August); 5 - 10 mg/l

2 Sodium sulphite Na_2SO_3

for reduction of oxygen and increasing of the pH-value

start with: 100 g / day = 80 ml / day

surplus in feed water: 0.2 - 0.3 mg/l
in boiler water: max. 20 - 30 mg/l

ANNEX 7

CHECK-LIST FOR WEEKLY CHECKS

The following have to be checked every week:

1	the functioning of safety valves:	by hand lifting
2	the functioning of low level cut-out:	during start-up procedure
3	the functioning of the pressure limiter:	during low load time (lunch time) by opening the air dampers and operation of induced draft fan
4	the condition of the grate:	particular the sliding plates
5	the production of ash:	ash removal
6	the pollution grate of the smoke tubes:	cleaning?

ANNEX 8

SETTING LIST

1.0 Safety equipment

1.1 Safety valves:	20 bar
1.2 Low level cut-out:	at N-W mark (red mark) = 770 mm from flange top edge
1.3 Pressure limit switch:	15 bar

2.0 Control equipment

2.1 Pressure controller for chips:	11 - 12 bar
2.2 Pressure controller for dust:	10 - 11 bar
2.3 Underpressure control:	0.8 mbar (set in special relay)
2.4 Water level control:	50 mm above N-W mark

3.0 Monitoring equipment

3.1 Combustion air temperature switch: (and indicator)	min. 500 oC max. 1.000 oC interlocked to dust feeding
3.2 Flow monitor for induced draft fan:	0.3 mbar
3.3 Fuel level monitor:	by construction 600 mm above filling flap
3.4 Stand-still monitor:	4.46-F10 (in panel)
3.5 Flow monitor dust fan:	limit switch 4.65-S7 (panel)

4.0 Other settings

4.1 Fuel spreader: by timer 4.36-k7 12/12 sec
by hydraulic speed 3.0/3.0 (setting)

4.2 Combustion air dampers:		day load	night load	stand-still
main dampers:	upper mm	40 - 50	20 - 30	0
	lower mm	30 - 40	20 - 30	10 - 15
secondary dampers:	flat grate	2/3	1	1
	fire box	2/3	1	0

4.3 Feed tank

steam pressure: 0.2 bar
at make-up water flow of 1.5 m3/h
only set by 2nd reducing valve

after boiling temp.: 100 oC

4.4 Water treatment plant

normal flow rate: 1.000 - 1.500 l/h
max. flow rate: 1.800 l/h
min. flow rate: 400 l/h

4.5 Raw water pressure: 3.5 - 4.5 bar

4.6 Dosing flow rate: normal: 35 %
which meet a daily supply of 70 - 90 l

4.7 Condensate discharge rate: between upper and lower level switch: approximately 5 min.

ANNEX 9

MAINTENANCE LIST

1.0 During operation

- daily blowing-through of the water level indicators:

  2 indicators at boiler
  1 indicator at feed tank
  1 indicator at condensate tank

- daily blowing-down of boiler water
- daily checking of feed pump packing
- daily checking of bearings
  (feed pump, induced draft fan, air fan)
- daily checking of leakages of valve packings
- daily checking of flange connections
- daily checking of correct settings of control equipment
- daily checks that no water drops onto electrical equipment
- daily blowing-out of the manometer valves

2.0 During shut-down

- weekly checking and correction of V-belt tension for induced draft fan and air fan
- weekly checking of grate wear and immediate repair, (enough cooling air)
- checking of wear of chain conveyor and repair
- checking of pollution of smoke tubes and if necessary cleaning of them
- removal of ash: step grate and flat grate

ANNEX 10

CHECK LIST FOR REGENERATION OF WATER TREATMENT PLANT

Preparation: if regeneration is done during normal operation time:
- fill-up the condensate tank
- keep the feed tank at normal level
  (otherwise dosing plant does not operate)

Regeneration:

1 switch-off the circulating pump and
close the ball valve after the pump

2 back rinsing: (2) + (3) + (4) 1)
25 min - 750 .... 400 l/h

3 sucking of NaOH and HCl concurrently: (5) + (6)
30 min - 300 .... 400 l/h transport water
9 l NaOH: position: 35 o) mark tank using ruler
10 l HCl : position: 45 o) for flow rate checking

4 slowly washing: (7) = (5.1)
30 min - 350 l/h

5 settling: (8) it takes more time than 10 min!
50 mm above resin level
do not forget to close valve 8!

6 mixing: (9)
20 min automatically

7 venting of nozzle bottom: (10)

8 filling-up: use valve 1 and not via 6 + 6.1
900 l/h

9 quick washing: (13) till conductivity lower than 1 uS/cm
(30 min - 1.300 l/h)

Checking of water:

SiO2 - test: lower 0.3 mg/l

---

1) Numbers in bracket relate to diagram supplied by the manufacturer.

ANNEX 11

POWER PLANT REPORT

MONTH:.....

1) PROCESS-DATA

Operating time:
1. from .../..... hr to .../..... hr
2. from .../..... hr to .../..... hr
3. from .../..... hr to .../..... hr
4. from .../..... hr to .../..... hr
5. from .../..... hr to .../..... hr

Interruptions:
1. from .../..... hr to .../..... hr
2. from .../..... hr to .../..... hr
3. from .../..... hr to .../..... hr

Consumptions weekly:	No	
Saw-dust	t	...../...../...../.....
Chips	t	...../...../...../.....
Make-up water	m3	...../...../...../.....

Operating facilities monthly:

Chemicals:	HCl:	l	.....
	NaOH:	kg	.....
	Sulfite	kg	.....
	Phosphate:	kg	.....
Lubricant:	Lubeoil:	l	.....
	Grease:	kg	.....
		kg	.....

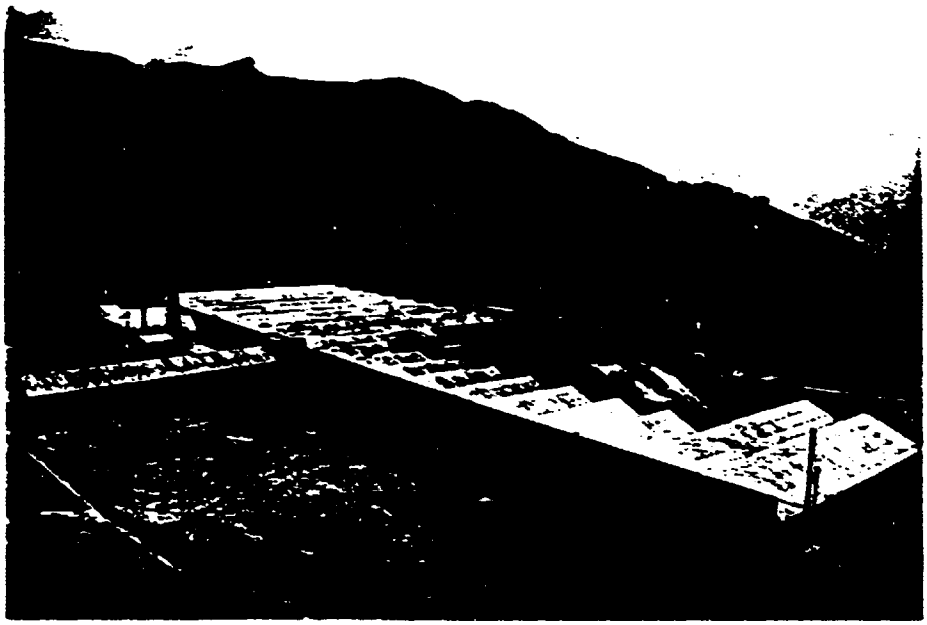
Regeneration of Watertreatment plant executed:.....
Capacity between two regenerations: m3 .....

Production weekly:	No	
Steam production:	t	...../...../...../.....
Condensate flow	t	...../...../...../.....
		...../...../...../.....
		...../...../...../.....

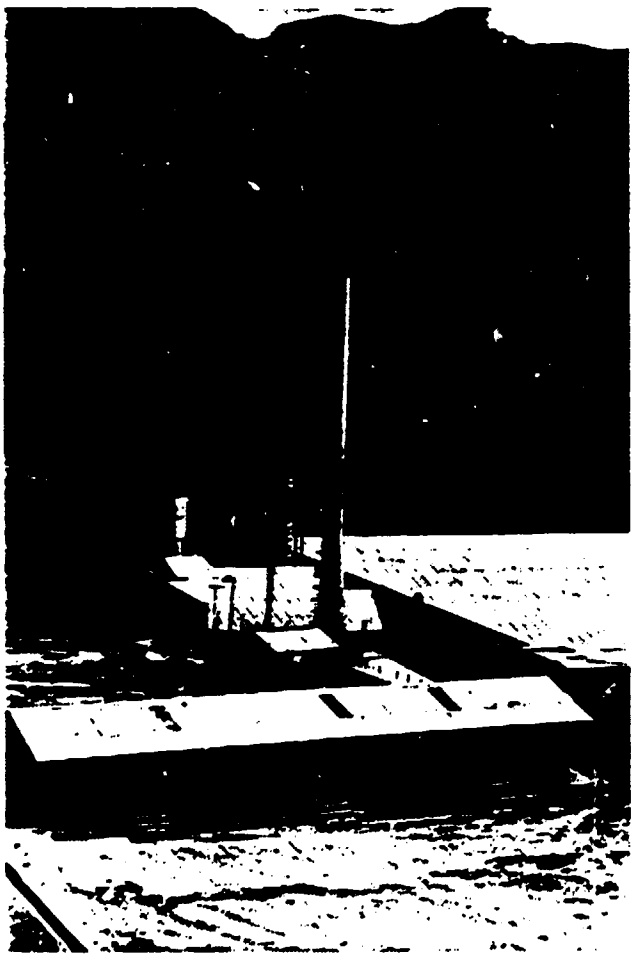
Waterquality (average value):

Raw-water:	hardness:	mval/l	.....
Make-up water:	conductivity:	micro S/cm	.....
	pH-value:		.....
Feed water:	pH-value:		.....
	Hydrazine:	mg/l	.....
Boiler water:	pH-value:		.....
	p-/m-value:	mval/l	..../....
	P205:	mg/l	.....
	density:	°Be	.....
	hydrazine:	mg/l	.....

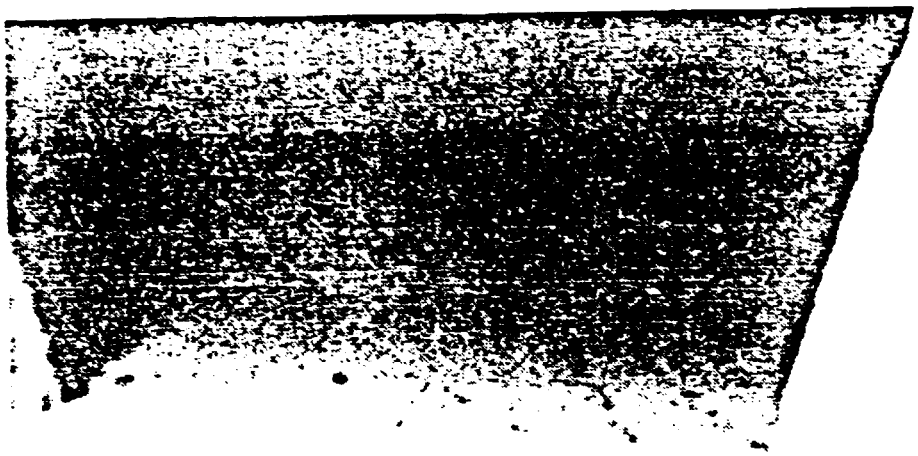
ANNEX 12

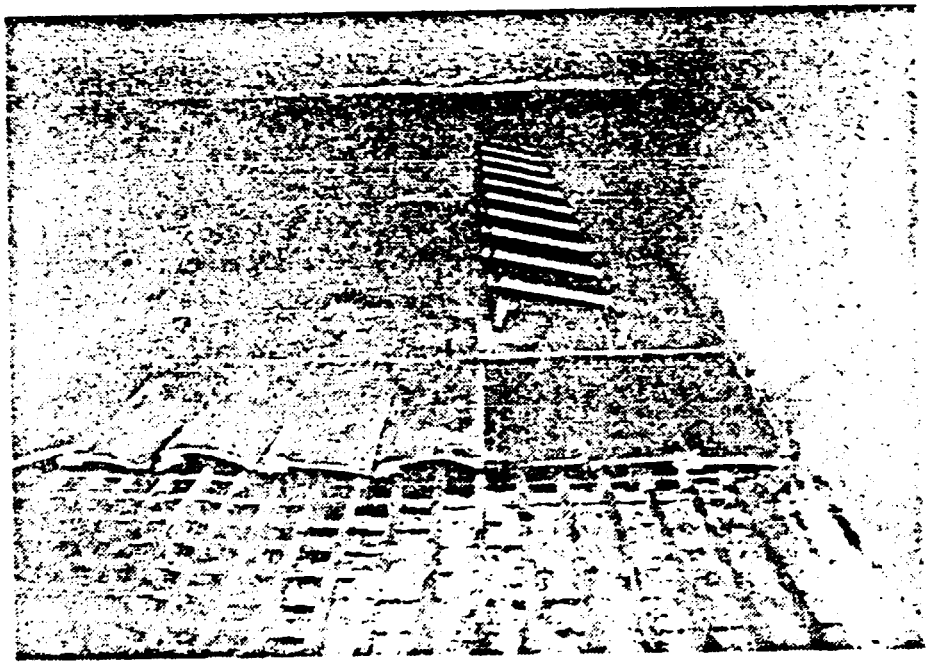


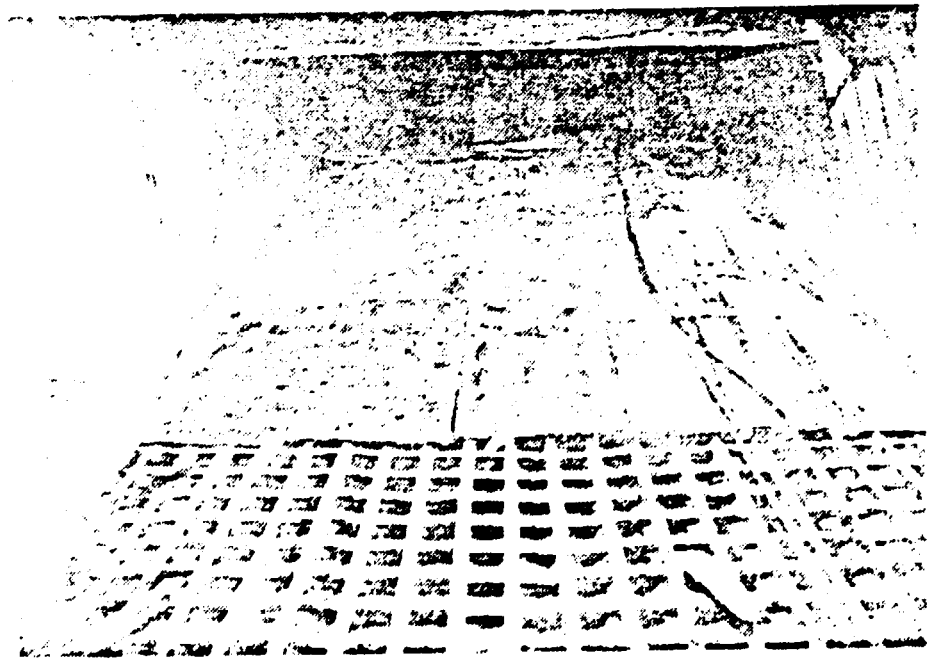
1.
GEDU-WOOD
COMPLEX

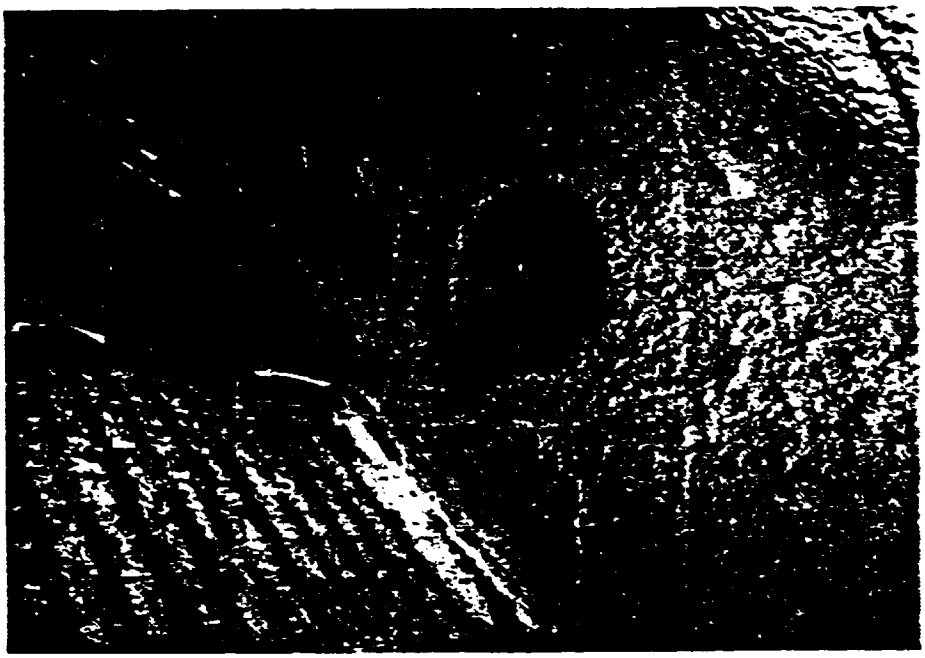


2.
Boiler Plant with
Silos and chimney

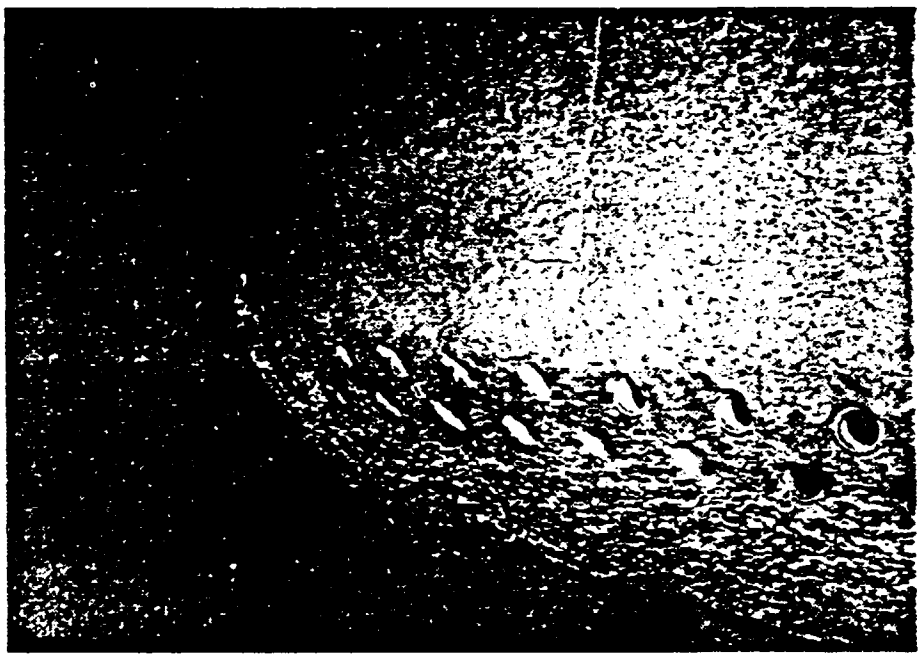




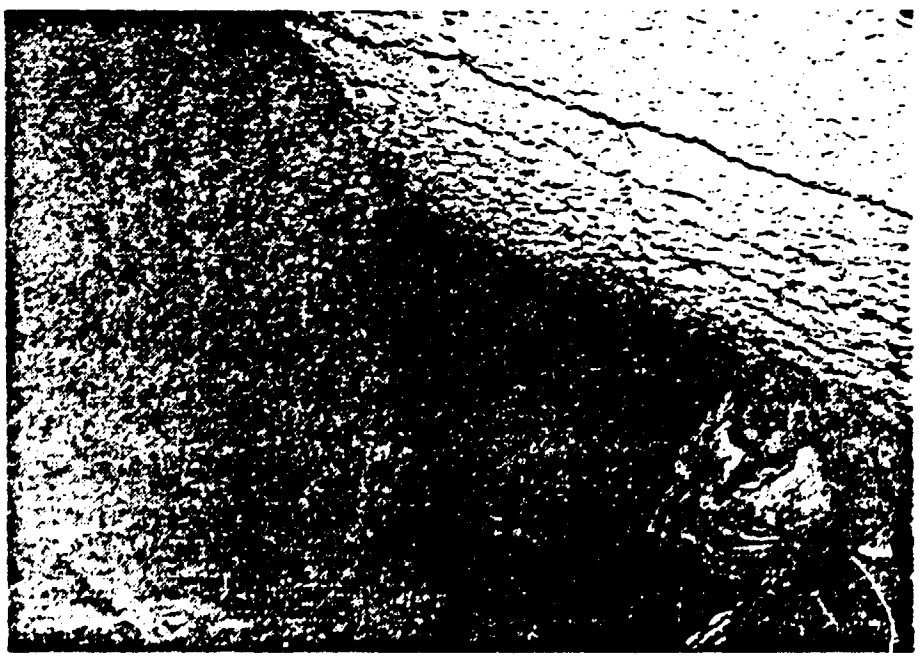




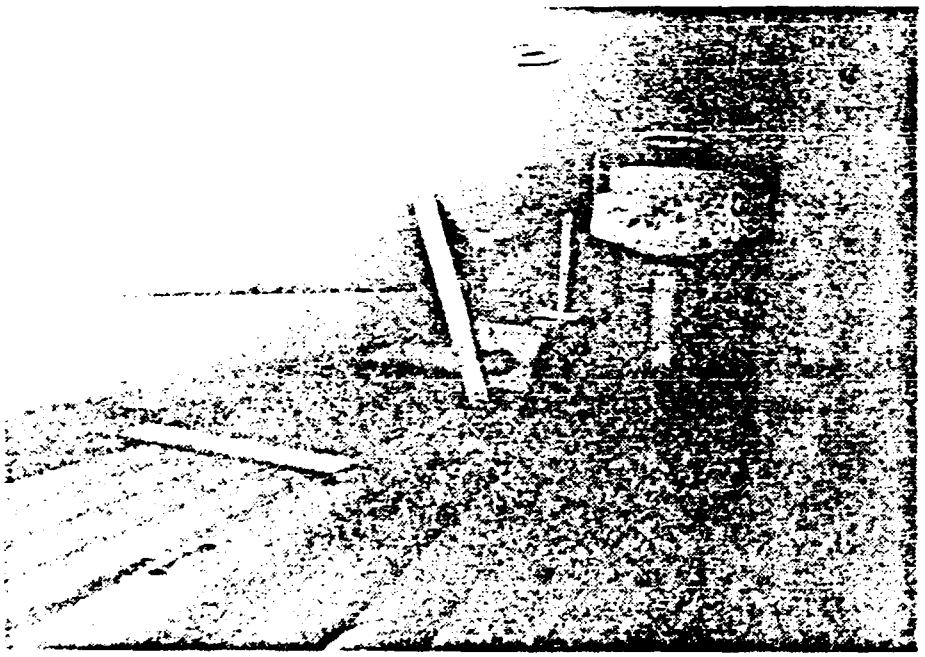
6.
Dust injector

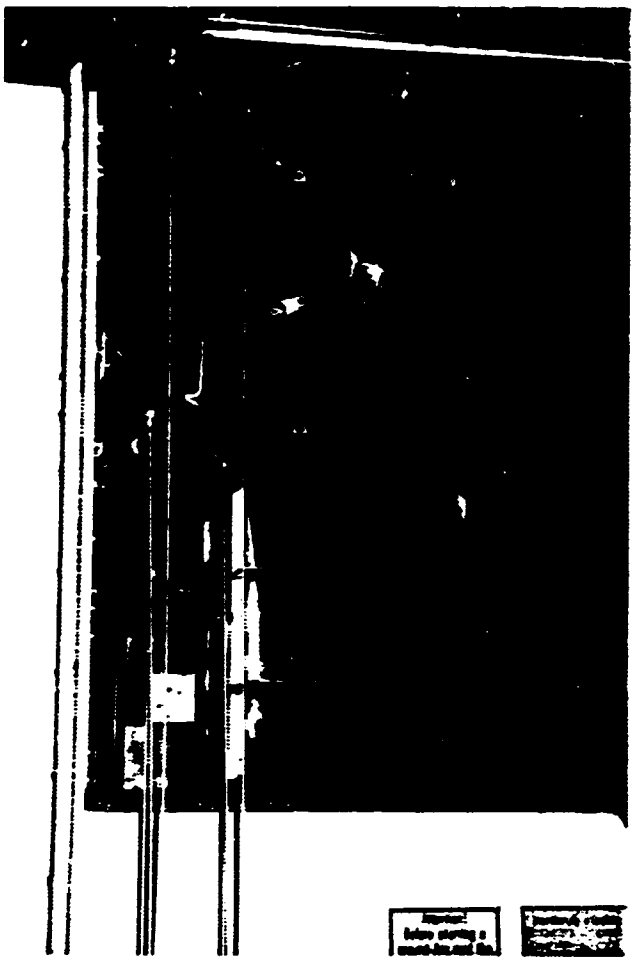


7.
Secondary chamber
air nozzles

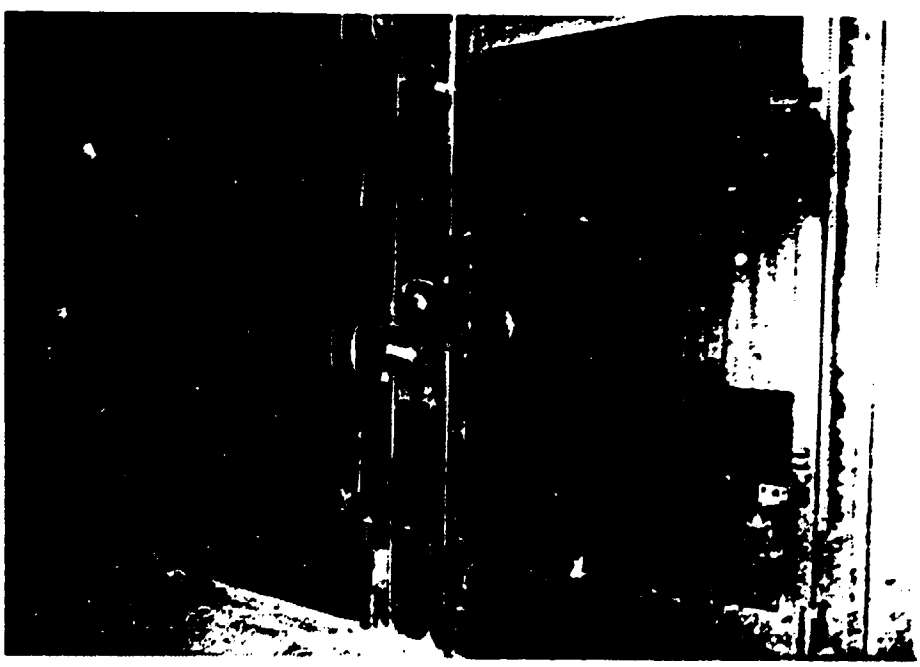


8.
Flue gas ash on the
furnace wall





12.
Overheated (burned fuel feeding equipment (double flap valve and spreader)



13.
COMBUSTION AIR DAMPERS
correct setting for full load