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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

19097

Distr.
RESTRICTED

IO/R.212
19 August 1991

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ORIGINAL: ENGLISH

BOILER ENGINEER TO THE GEDU WOOD MANUFACTURING CORPORATION

UC/BHU/91/037

KINGDOM OF BHUTAN

Technical report: Second mission for the assessment of the boiler plant at the Gedu Wood Manufacturing Corporation*

Prepared for the Government of the Kingdom of Bhutan
by the United Nations Industrial Development Organization

Based on the work of Manfred Wettemann, boiler expert

Backstopping officer: Antoine V. Bassili
Agro-based Industries Branch

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* Mention of firm names and commercial products does not imply endorsement by the United Nations Industrial Development Organization. This document has not been edited.

V.91 28027

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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 Engineer, undertook additionally to the four week mission in 1989 a second mission to Gedu (Bhutan) from 30th April to 22th May 1991.

Refering to the first mission see technical report of DP/ID/SER.A/1248 dated of 12th September 1989.

EXPERT SERVICE

In addition to the first mission a second mission was performed after purchasing and availability of some important spare parts and equipment for additional installations.

The tasks of the first mission were:

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

The tasks of the second mission were:

- inspection of the boiler plant
- further training of the operating people
- supervising of maintenance, repairs and improvements
- checking of the operation and function of the water treatment plant and the results for the water quality
- recommendations about spare parts
- checking of the steam and condensate piping system
- completion of the operating and maintenance instruction manual (of the manufacturers)

02) GENERAL INFORMATION

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

There has been no change of the production of the Gedu Wood Complex:

- plywood mill: 2 shifts
- sawmill: 2 shifts
- joinery: 1 shift

The boiler plant is operating 24 hours a day from:

Monday 5:00 h till Saturday 24:00 h

There are still the same heat consumers:

- 3 veneer dryers: 10 - 12 bar
- 1 hot press: 5 bar
- 1 block press: 3.5 bar
- 6 steam vats: [illegible] bar
- 3 kiln dryers: 3 bar

max. heat demand of the total plant: 6.0 t/h saturated steam
max. operating pressure/temperature: 13 bar/195 oC (roller dryer)

Boiler plant:

capacity:	7.5 t/h
max. operating pressure:	20 bar/215 oC
normal operating pressure:	12 bar
normal boiler load:	4.0 t/h
steam generation:	95.0 t/day

Water treatment plant:

capacity:		70 m3
make-up water generation:		25 m3/day
Chemical consumption:	30 % HCl	18 l/week
	45 % NaOH	16 l/week

03) INSPECTION OF THE PLANT (boiler inspection)
Checks and findings

It has now been 2 years since the last inspection conducted by the expert.

Half a year ago the boiler was shut down by the Gedu Wood people for cleaning and repairs of the furnace.

Due to the abovementioned shut down and the big production the boiler plant was only shut down for 2 days in order to perform the minimum works as:

- repairs in the furnace: - concrete support for lower step grate bars
  - replacing of the sliding plates by new ones
- improvements fuel infeed system
- additional installations

Fuel feeding:

refer to paragraph 6)

Furnace inspection:

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

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

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

Drum inspection:

The boiler drum was not emptied. Therefore the drum's inside was not inspected.

According to the boiler water quality there is no need to worry about scale covering in the drum.

Water treatment plant:

refer to paragraph 7)

Operation:

The water level control was not working automatically. Since half a year one man had to control the water level by hand. The problem was solved by fixing of a loose cable connection at the actuator.

The double flap valve of the fuel feeding system did not work in the correct opening sequence: the upper flap was too short open.

The fuel did not cover the grate correctly. The material was collected too much at the bottom of the furnace: The sliding angle of the lower step grate bars were too steep. Furthermore, the sliding plates were burned and bent.

General Condition:

The boiler plant and the water treatment plant are generally in a good condition.

04) REPAIRS, MAINTENANCE AND IMPROVEMENTS

During the boiler shut down the following repairs and maintenance were carried out:

Main works:
- grate repairs: the burnt sliding plates were replaced by new ones
  a concrete support was built for the lower step
  grate bars in order to improve the sliding angle
- 2 maintenance doors were provided at the double flap valve of the fuel infeed duct
- some gaskets in the main steam line and packings were renewed
- 2 stop valves were installed at the feed water pumps
- 3 hydraulic valves were replaced by new ones
- 1 return filter was replaced by a new one
- cleaning of all smoke tubes

Electrical feed pump:

During replacment of the packing material it was found that the shaft was damaged at the bearing seat. The pump had to be dismantled totally and brought to RTI (Royal Technical Institute) for overhauling of the damaged shaft.

Future improvements:

- a fire concrete beam shall be provided instead of the sliding plates which have to be renewed once a year
- the fuel stops in the double flap valve can be prevented by providing a faster program relay (4.35 K6). Instead of 30 sec the rotating time should be 20 sec
- the fuel spreader shall be replaced by one made of cast iron

Control panel

- the programm relay 4.35 K6 which controls the double flap valve was repaired and set to a shorter time
- a lot of relays and conductors had to be relabeled

Water treatment plant
---
refer to paragraph 7

05) SETTINGS OF SAFETY AND CONTROL EQUIPMENT

There are 2 safety valves for the boiler. Both were checked at the low-load time. The set pressure is 20 bar. One of them was set lower to 17.5 bar.

The safety pressure switch was set to 15 bar.

The operating pressure was set higher according to the requirements of the heat consumers (to increase the capacity of the roller dryer: operating temperature 190 oC):

- chips: 11/12 bar
- dust: 10.5/12 bar

The low level cut out was checked during operation: OK

The water level control was repaired and re-adjusted:
It is now operating more stably at a higher level.

The underpressure control was checked: no change, no problem: OK

The heating steam system of the degasifier was checked and found OK.

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

Double flap valve: rotating time: 30 sec (7.5 + 7.5 + 7.5 + 7.5)

Fuel spreader: time relays 4.36 K7: right side: 15 sec
left side: 7.5 sec

Continuous blow-down valve: set to the minimum flow rate: 60 l/h

The Condensate level control at kiln-dryer station: due to the low conductivity of the condensate (lower than 10 micro S/cm) the electrodes have to be cut and deinsulated for a proper length (reference electrode was deinsulated totally). The amplifier was connected according to a revised diagram: After these improvements the pump switches on/off automatically. Previously the operator of the kiln-dryers had to monitor all the time the condensate pump station and to switch the pump manually on/off.

All the above mentioned settings are established in the revised setting list given in Annex 3.

06) FUEL SUPPLY AND FEEDING

So far, there are still problems with fuel stoppings in the double flap valve, especially in the big load time when the fuel rate is larger than 1,200 kg/h.

The present flow rate is:
gear box position A: 1,055 kg/hr
B: 1,165 kg/hr
C: 2,000 kg/hr

The programm relay 4.36 K6 controls the opening of the double flap valve. The rotation time of the relay is minimum 30 sec. A relay with a shorter rotating time e.g. 20 sec would increase the loadings per hour and improve the fuel feeding.

2 maintenance doors were installed in order to remedy the fuel stops in the double flap valve.

The present fuel spreader looks very bad. It should be replaced by a new one made of cast iron.

The hydraulic unit which operates as drive unit for the fuel feeding system was checked and serviced: 3 solenoid valves and 1 filter were replaced by new ones. The hydraulic lines were vented. This maintenance was an excellent training for the operators. Now they know the function of the unit and how it works.

Recommendation:

The remote roof of the feed conveyor between the chipper and the chip silo shall be replaced because of the heavy rain falls in Gedu. Sometimes the chips are too wet and the fuel feeding system is overloaded in the big load period (the mass flow is bigger due to the low calorific value of wet material). This can be easily solved locally.

Combustion of bark

There is a lot of bark waste at the plant and the management asked about burning of bark: The existing furnace is provided with an inclined step grate which is suited for wet fuel. As bark contents a lot of soil the grate can be stopped by slag (cinder). Depending on the soil content and the mixing rate the grate has to be cleaned (removal of slag) more often than without burning bark.

The expert suggests to start with burning bark by a mixing rate of 20 % of the total volume of the chips. After some weeks experiences the mixing rate can be decreased or increased according to the stopping of the grate and the possibility for cleaning (only on Sundays).

At the beginning the bark should be fed after the silo into the chain conveyer. After some experience the bark can be fed into the chips silo for better mixing in the rate recommended above.

07) WATER TREATMENT AND CHEMICAL DOSING

During the first mission two effective regenerations were performed (repeating):

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.

At the beginning of the 2nd mission a raw water flow meter (upstream the water treatment plant) was installed . After this installation the exact daily make-up water requirement could be found: 25 m3 which is 25 % of the steam rate.

The capacity of the mix bed exchanger could now checked not by calculation but by measuring the flow rate between 2 regenerations. After 70 m3 the conductivity and the silicate content increased. This new information means that 2 regenerations have to be performed a week instead of once in 2 weeks.

The following inspection, repairs, maintenance and improvements were carried out:

- by open mix bed exchanger (tank) the resin was washed in overflowing water. After washing the total resin was brought out to clean the tank and the nozzles inside. After cleaning the resin was taken into the tank and missing anion resin was added: 12 l

- in order to increase the actual capacity further 13 l old anion resin were replaced by new one and a acid washing (by 10 % HCl) was performed.

- repairs of PVC-piping

- improvements at the injectors for acid and lye sucking by increasing the nozzle diameter. But there was not much advantage. The sucking time takes minimum 30 min by using of lot of tricks.

Conductivity meter

The installed conductivity meter indicates 10 times lower a value than the real value. This was found by using a brand new hand meter and checking the technical data of the installed meter. The cell constants of the meter and the cell are not identical. The cell constant is 0.1 and the one of the meter is 0.01. This means that the indicated value has to be multiplied by 10. The operators have been instructed accordingly. There is no further action.

As the conductivity measuring of the water quality is so important (make-up water, feed water, condensate and boiler water) the hand meter which the expert brought with him was taken over by Gedu Wood for comparision and to serve as a spare.

Exchanger resin

According to the demand of Gedu Wood 25 kg new anion resin were supplied for refilling of missing resin. After opening the supplied sack, it was found that the resin had the same colour as the cation resin. This was a problem for regeneration because the separation cannot be checked by the operator.

The expert claimed this to the supplier. Result: 50 l cation and 100 l anion resin will be supplied to Gedu Wood for replacing the total existing resin.

The resin used at present (samples taken by the expert) was checked by the supplier: cation resin 15 % capacity loss, anion resin no capacity loss. Sofar, there is no real capacity loss only the separation during the regeneration takes more time (checking of the separation).

Regeneration

The revised instructions of the regeneration were recorded in a check list given in Annex 5.

Injectors

In order to shorten the sucking time of acid and lye the existing injectors should be replaced be new ones of bigger size.

The expert will find out the correct size and will send them together with other useful parts.

Raw water quality

The hardness and the silicate can be totally eliminated by the existing mixed bed ion exchanger. But the raw water takes a lot of organic particles into the filter which remain in the resin. If the raw water will never filter properly a lot of sludge will be collected in the resin and the capacity goes down.

There is a filter installed in the raw water supply line which was never used because there is no filter insert for collecting the dirt. The expert will find out a washable filter insert for using in future. This is not costly but very useful.

The water treatment plant was working well after the above mentioned repairs and improvements. The still existing problems will be solved in near future. The regeneration can be carried out by the operators.

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 water quality required was revised: refer to Annex 2

The thermal degasifying was working well; there was no need to change the setting.

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). In the last 2 years sodium sulphite was used, however there is a problem to measure the excess of sulphite in the water. Further sulphite does not protect the steam and condensate piping.

Therefore the expert suggests to use in future hydrazine or levoxine instead of sodium sulfite. This chemical agent does not only bind the residual oxygen but it goes with the steam into the piping system and protects the inner wall against corrosion. This is very important for the total piping system which are now more than 5 years old. Hydrazine can be purchased in India. The consumption is about 2.5 kg per month.

Chemical dosing

After checking the water quality of feed and boiler water the chemical dosing rates were decreased, refer to Annex 4.

The following chemicals are injected into the feed water tank:
- trisodium phosphate Na3PO4 (to bind silicate)
- caustic soda NaOH (to increase the pH-value)
- hydrazine N2H4 (to bind residual oxygen)

The dosing will be performed independently from the level switch in a continuous rate by the new manual/auto switch: 70 l/day

Due to the good water quality the testings were reduced to the following examinations:

- conductivity: make-up water
  feed water
  condensate
  boiler water
- pH-value: feed water
  condensate
  boiler water
- hydrazine: feed water
  boiler water
- silicate: make-up water
- phosphate: boiler water

The major tests are for conductivity and pH-value.

The present water quality is as follows:

make-up water:	conductivity:	2.2 microS/cm
	pH-value:	5.5
	SiO2:	0
feed water:	conductivity:	5.8 microS/cm
	pH-value:	7.5
condensate:	conductivity:	1.9 microS/cm
	pH-value:	7.0
boiler water:	conductivity:	230 microS/cm
	pH-value:	above 10
	P2O5:	10 mg/l

08) TRAINING FOR OPERATION, RECORDING AND CALCULATION

On the basis of the first mission and the foreign training of the boiler supervisor Mr. Lekhi Dorji in UK the training could be extended especially in:

- general knowledge of the function of the plant (controlling)
- setting of controllers and relays
- monitoring (fire formation, grate covering)
- repairs (feed pump, PVC-piping)
- maintenance (instruments, valves, hydraulic unit)
- reading and calculation of raw and feed water flow
- daily reporting of operating data,
  consumption and
  water quality
- calculation of steam load
  continuous blow down rates
  fuel consumption
- revised regeneration
- identification of pipes, valves and fittings
- reading of steam pressure/temperature table
- reading of valve and flange table
- sequence of spare parts ordering
- design and construction of heat exchanger for steam vats

Reading and Reporting

Due to the newly installed flow meters for raw water and boiler feed water the real consumption and the boiler load could be found out.

the actual consumption is of raw water: 25 m3/day
feed water: 95 m3/day

Based on these data:
- the boiler load diagram could be drawn up: refer to Annex 1
- the correct dosing rate can be calculated.
- the correct blow down rate can be calculated.

For the daily and monthly reports the following charts were drawn up:
- Shift report (operating data) - Annex 6
- Daily report of boiler plant (consumption) - Annex 7
- Monthly report of boiler plant (consumption) - Annex 8
- Protocol of regeneration - Annex 9

09) ADDITIONAL INSTALLATIONS

As recommended in the report of the first mission the following additional installations were carried out:

1) Water treatment plant:

   flow meter (counter) DN 20 in raw water 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 pipes
   (for repairs and maintenance)

4) Condensate tank:

   2 stop valves DN 20 PN 10 at the level indicator (maintenance)

5) Boiler:

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

6) Fuel supply

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

10) SPARE PARTS, TOOLS, OPERATION FACILITIES, INSTRUMENTS

There are still not enough spare parts because of foreign exchange problems. For this reason the major part of the spare parts have to be purchased in India:

- refractory material
- piping material
- gaskets and other sealing material
- main electrical parts
- bearings and belts
- electric motors

But there are some important special parts which have to be purchased from Germany. The following spare parts were recommended and offered to Gedu Wood:

1 actuator for feed water control valve
1 actuator for control valve at the kiln dryer
1 water level controller
1 thermo couple for fire chamber
1 program relay
1 time relay

1 hand conductivity meter was kept by Gedu Wood

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 spare part list made in the report of the first mission.

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 2 years.

Trisodium phosphate (Na_3PO_4) and Sodium sulphite (Na_2SO_3) is available from India.

As recommended in paragraph 7 hydrazine or levoxine shall be used instead of sodium sulfite in future. These chemicals are also available in India.

The consumption of the chemicals is as follows:

- HCl (30%): 2x9 ltr/week = 900 ltr/yr (in store: 2.000 ltr)
- NaOH (45%): 2x8 ltr/week = 800 ltr/yr (in store: 2.000 ltr)
- Na3PO4(20%): 0.2 kg/day = 5.0 kg/month = 60 kg/yr
- N2H4 (15%): 0.1 kg/day = 2.5 kg/month = 30 kg/yr

Water Test Kits:

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

1 chemical filling pump (hand-pump) was purchased from Germany (filling-up of the storage tank of the regeneration agents) which was very useful and important for the security of the operators.

11) STEAM AND CONDENSATE PIPING SYSTEM

There is a large distributed piping circulating system which transports the saturated steam to the consumers and leads back the condensate to boiler plant:

- 3 veneer dryers
- 1 hot press
- 1 block board press
- 6 steam vats
- 3 kiln dryers

The steam pipes are designed for PN 40 .
The condensate pipes are designed for PN 16.

All important technical data relating to valves, flanges, steam traps were compiled for ordering of spare parts. During this work the boiler supervisor was trained in reading of the flange and valve tables and the standards.

Most of the spare parts can be purchased in India (Spirax Sarco Bombay).

Furthermore, all steam traps strainers and fittings at the veneer dryers were checked to find out whether it is possible to increase the operating pressure for higher capacity.

In order to increase the drying capacity of the roller dryer the operating pressure of the heating steam had to be set from 10 to 12 bar (at the boiler). For this reason the existing safety valve had to be set from 12 to 13.5 bar (design pressure PN 16).

The distant installed condensate collecting unit at the kiln dryers was checked and repaired for automatic operation, (refer to paragraph 4).

Steam vats

There are 6 vats for boiling of logs before peeling. The Boiler water is heated up by the installed pipe heat exchangers. As the boiling water is very corrosive the heat exchangers have to be repaired at short intervals. The expert proposed and sketched a removable heat exchanger. The heat exchanger is connected only at 2 flanges (steam and condensate) and supported by 3 feet on the bottom. By using this type the repair of the corroded pipes can be carried out externally. Furthermore, the cleaning of the vats by removing of the heat exchangers is much easier and more effective. The removal can be done by the existing overhead crane.

Recommendation

As already mentioned in paragraph 7 hydrazine shall be injected to the feed water for protection of the steam and condensate piping.

12) REVISIONS OF PREVIOUS ADVICE

The following lists were revised and handed over to the boiler supervisor:

- check list for operating data (Annex 2)
- check list for chemical dosing (Annex 4)
- setting list (Annex 3)
- check list for regeneration of water treatment plant (Annex 5)

ANNEX 1

REVISED CHECK LIST FOR OPERATING DATA

Steam pressure	bar	11 - 12
Load (pos.of contr.valve)	mm	5 - 11 (= 2 - 6 t/hr)
Underpressure	mbar	0.6 - 1.2
Combustion temperature	oC	600 - 900
Flue gas temperature	oC	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	%	0 (= 60 l/hr)

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

				Frequency (days/week)
Make-up water	conductivity	uS/cm	less 10	6
	SiO2	mg/l	less 0.3	2
	pH-value		5 - 8	1
Feed water	pH-value		7 - 9.5	6
	hydrazine	mg/l	0.1 - 0.3	6
	conductivity	uS/cm	less 10	6
	resid. hardness	odH	0.02	1
Boiler water	pH-value		above 10	2
	phosphate	mg/l	5-10	2
	conductivity	uS/cm	less 1000	6
	SiO2	mg/l	less 100	1
	resid. hardness	odH	0.1	1
	p-value	mval/l	1 - 5	1
	hydrazine	mg/l	0.1	1
Condensate	conductivity	uS/cm	less 3	1
	pH-value		7	1

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 2

REVISED SETTING LIST

1.0 Safety equipment

1.1 Safety valves:	1x20 bar, 1x17.5 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:	11 - 12 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 — 15/7.5 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: 30 % (continuous run)
which meet a daily supply of 70 - 90 l

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

4.8 Double flap valve by timer 4.35 K8: Impulse every: less than 1 sec.
Duration of impulse" 7.5 sec.

ANNEX 3

REVISED 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

   rated: 0.2 - 1.0 g/m3 feed water
   as there is a daily feed water flow rate of 90 - 100 m3
   the daily dosing rate should be:

   50 - 100 g/day

   but limited to an excess of
   the phosphate-content (P_2O_5) in the boiler water:

   5 - 10 mg/l

2) Hydrazine or Levoxine N_2H_4 (15 %)

   50 - 100 g/day

   for an excess in feed water of 0.1 - 0.5 mg/l

   for reduction of oxygen and protection of the steam and condensate piping.

3) Caustic soda NaOH (45 %)

   to increase the pH-value of feed water (above 8.5) and boiler water (above 10).

   50 ml/day

ANNEX 4

REVISED CHECK LIST FOR REGENERATION OF WATER TREATMENT PLANT

When the conductivity is more than 5 microS/cm
and/or the SiO2-content is more than 3 mg/l
which correspondences with a raw water flow of 70 m3
then the mixed bed ion exchanger has to be regenerated.
This is normally twice a week.

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)
60 min - 600 l/h to the conductivity of 100 microS/cm

5 settling: (8) by valve 10 + 12 + 4
50 mm above resin level
do not forget to close valve 8!

6 mixing: (9)
10 min automatically

7 venting of nozzle bottom: (10)

8 filling-up: use valve 1 and 4
900 -1.500 l/h

9 quick washing: (13) till conductivity lower than 10 microS/cm
(20 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.

DAILY REPORT OF BOILER PLANT

Date: .....

1.0 Boiler load at:		9:00	17:00	1:00
1.1 valve position	mm			
1.2 refer to flow rate	t/h			

2.0 Consumption

2.1 make-up water	m3		.....
2.2 feed water	m3		.....
2.3 chips	hr	..... x 1.100 kg/hr =	.....
2.4 dust	hr	..... x 270 kg/hr =	.....

3.0 Steam production

3.1 feed water (2.2) x 0.95 = t .....

4.0 Water quality

4.1 raw water	conduct.	.....
4.2 make-up water	conduct.	.....
4.3	SiO2	.....
4.4 feed water	conduct.	.....
4.5	pH-value	.....
4.6	hydrazine	.....
4.7 boiler water	conduct.	.....
4.8	pH-value	.....
4.9	phosphate	.....
4.10	hydrazine	.....
4.11 condensate	conductivity	.....
4.12	pH-value	.....

5.0 Regeneration

5.1 time: from ..... to .....

5.2 consumption of raw water:	m3	.....
5.3 consumption of HCl:	l	.....
5.4 consumption of NaOH:	l	.....

6.0 Chemical dosing

6.1 Na3PO4	g	.....
6.2 N2H4	ml	.....
6.3 NaOH	ml	.....

MONTHLY REPORT OF BOILER PLANT

Month: .....

Interruptions: reason:

1. from ...../.... to ...../....
2. from ...../.... to ...../....
3. from ...../.... to ...../....

Consumption:

- chips t
- dust t
- make-up water m3

Chemicals: HCl l
NaOH l
Na3PO4 kg
N2H4 kg

Lubricants: lube oil l
grease kg

Steam production: t

Water quality:

make-up water: conduct. uS/cm
feed water: conduct. uS/cm
pH-value
N2H4 mg/l
boiler water: conuct. uS/cm
pH-value
P2O5 mg/l
hydrazine mg/l

Repairs:

Spare parts needed:

Improvements:

Maintenance and cleaning:

- fuel feeding
- combustion chamber
- drum
- pumps
- water treatment plant
- piping

GEDU WOOD SHIFT REPORT of BOILER PLANT

Date: .....

operating data

1) h=hight, m=medium, l=low
2) bl=blue, ye=yellow, re=red

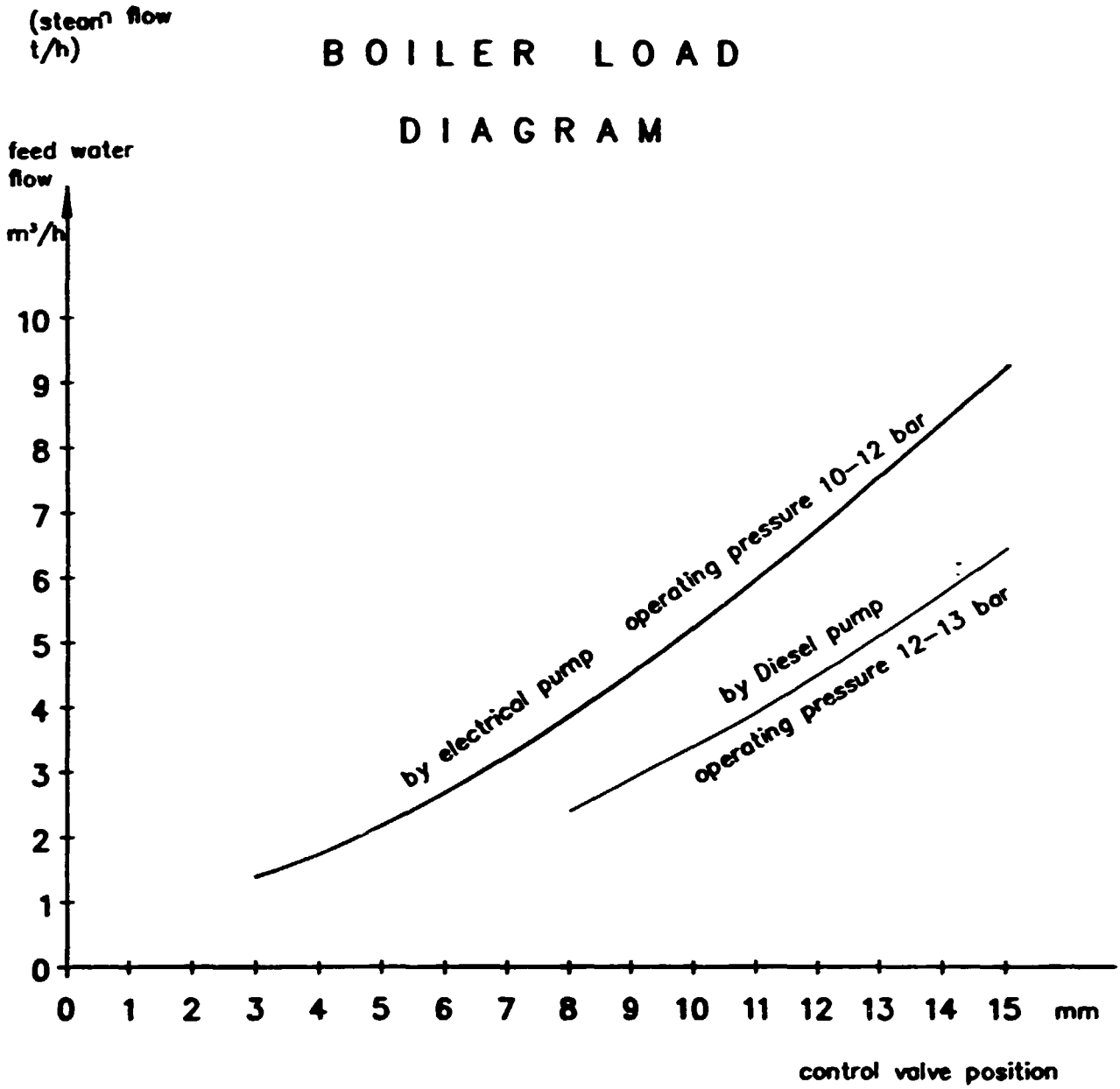
Time	steam press. bar	valve position	under pressure	combustion temperature	flue gas temperature	feed tank pressure	feed tank temperature	cond. tank temperature	blow down	1) boiler level	2) feed tank level	1) cond. tank level	chips hr	dust hr	raw water m³	feed water m³
	bar		mbar	°C	°C	bar	°C	°C	sec				hr	hr	m³	m³
1:00																
2:00																
3:00																
4:00																
5:00																
6:00																
7:00																
8:00																
operator																
9:00																
10:00																
11:00																
12:00																
13:00																
14:00																
15:00																
16:00																
operator																
17:00																
18:00																
19:00																
20:00																
21:00																
22:00																
23:00																
24:00																
operator:																
average:																
total consumption:																

Remarks:

		< 10	< 3,0	m^3	l/min.			m^3				

		µS/cm < 10	ppm < 3,0	beginning m³	HCl + NaOH l/min.	µS/cm–min.	µS/cm–min.	end m³	m³	m³	
1	8.5.91	–	≫ 3,0	53,70	10+10/60	100 – 65	70 – 25	56,05	2,35		
2	11.5.91	7	> 3,0	125,3	10+75/90	100 – 86	72 – 20	730,5	5,2	69,35	replacement of 12 l anion resin
3	15.5.91	24,5	≫ 3,0	204,75	10+9/40	700/69	78 – 72	206,95	2,1	74,25	sep. measurings after slow wash
4	18+19.5.91	4,5	> 3,0	279,7	5+9/60	94/70	70 – 70	282,5	2,8	72,85	acid washing additional 15 l anion resin

BOILER LOAD DIAGRAM



BOILER PLANT
Saturated steam 10 – 12 bar

GEDU WOOD CORP.
B H U T A N