OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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

RESTRICTED

17654

DP/ID/SER.A/1227
7 July 1989
English

HIGH LEVEL CONSULTANCIES AND TRAINING

DP/SYR/86/009

SYRIAN ARAB REPUBLIC

Technical report: Maintenance and operation of mechanical components in sugar plants*

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

Based on the work of Zoltan SZABO, expert in maintenance and operation of mechanical components

Backstopping officer: G. Anestis,
Section for Integrated Industrial Projects

United Nations Industrial Development Organization

Vienna

* This document has not been edited.

2/

V.89 57572

I. PURPOSE OF PROJECT

The project was aimed at assisting the Government of the Syrian Arab Republic in assessing the effectiveness of various mechanical components in industrial plants producing fertilizers and sugar and to develop and supervise R+M programmes in order to ensure a stable operation of the respective plants and related equipment.

The assignment was splitted for:

General Establishment for Chemical Industries, and

General Organisation for Sugar.

A. General Organisation for Sugar

The General Organisation for Sugar situated in Homs manages the following companies/factories:

- Homs Sugar Company for = sugar beet production and raw sugar refining,
  = alcohol production,
  = cotton seed oil production, and
  = wet yeast production.
- Adra Sugar Company (the unit is stopped and partially dismantled).
- Al Gab Sugar Company for sugar beet production and raw sugar refining.
- Tal Salhab Sugar Company for sugar beet production.
- Maskana Sugar Company for sugar beet production.
- Raqqa Sugar Company for sugar beet production.
- Der Zor Sugar Company for sugar beet production.

- Damascus Yeast Factory for wet yeast production.
- Aleppo Yeast Factory for wet and dry yeast production.
- Harasta Yeast Factory for wet yeast production.

The campaign period in Syria starts at July, therefore most of the units were out of operation.
The request of the management of General Organisation for Sugar was to concentrate on and visit the Homs, Al Gab and Tal Salhab Sugar Companies and Harasta Yeast Factories.
The key problems are the steam distribution, high fuel consumption, steam turbines and boilers operation and maintenance.
Since the mission period was outside the beet campaign and the factories were fully or partly out of operation, most of the operational parameters are to be considered as second-hand information.

II. HOMS SUGAR COMPANY

The Company comprises the following factories:

- Sugar factory for sugar beet production and raw sugar refining (only the sugar refining sections was started just at the end of the mission period)

Design capacity	1000 ton beet/day
Average effective capacity	900 ton beet/day
Fuel consumption	101 kg fuel/ton of beet

- Alcohol factory (out operation because of shortage of raw material)

Design capacity	2000 ton/year
Effective capacity	6 ton/day white alcohol + 1 t/d blue alcohol

- Cotton seed oil factory (in operation)

Capacity	100 ton/day cotton seed
Product	14-15 t/day oil
	or 90 tons/day sunflower seed → 30 tons/day oil

- Yeast factory (out of operation because of shortage of raw material)

Design capacity	10 tons/day
Effective capacity	10-12 tons/day

- Soap unit

Capacity	2 tons/day

The units of the Company are very old except for the yeast factory and some sections of the sugar factory. Due to this fact, efficiency and yield are acceptable in these sections. The main problem of the Company is the utility supply. The simplified block diagram is shown in Fig. 1.

Boilers IA, IB, IC (out of operation because not needed at this time) were built in 1948, their capacity is 10 tons/hour for each. The burners are manually controlled. According to second-hand information received, the maximum achieved superheated steam temperature is 250°C in these boilers, which could be considered to be the result of fouling in the tubes of the superheater and also the reduction of heat-transfer surfaces.

Boiler II with 24-27 tons/hour capacity was built in 1954, boiler III with 35 tons/hour capacity was built in 1968. During the campaign period usually these boylers are operating. The achieved superheated steam temperature is about 430°C, which is acceptable.

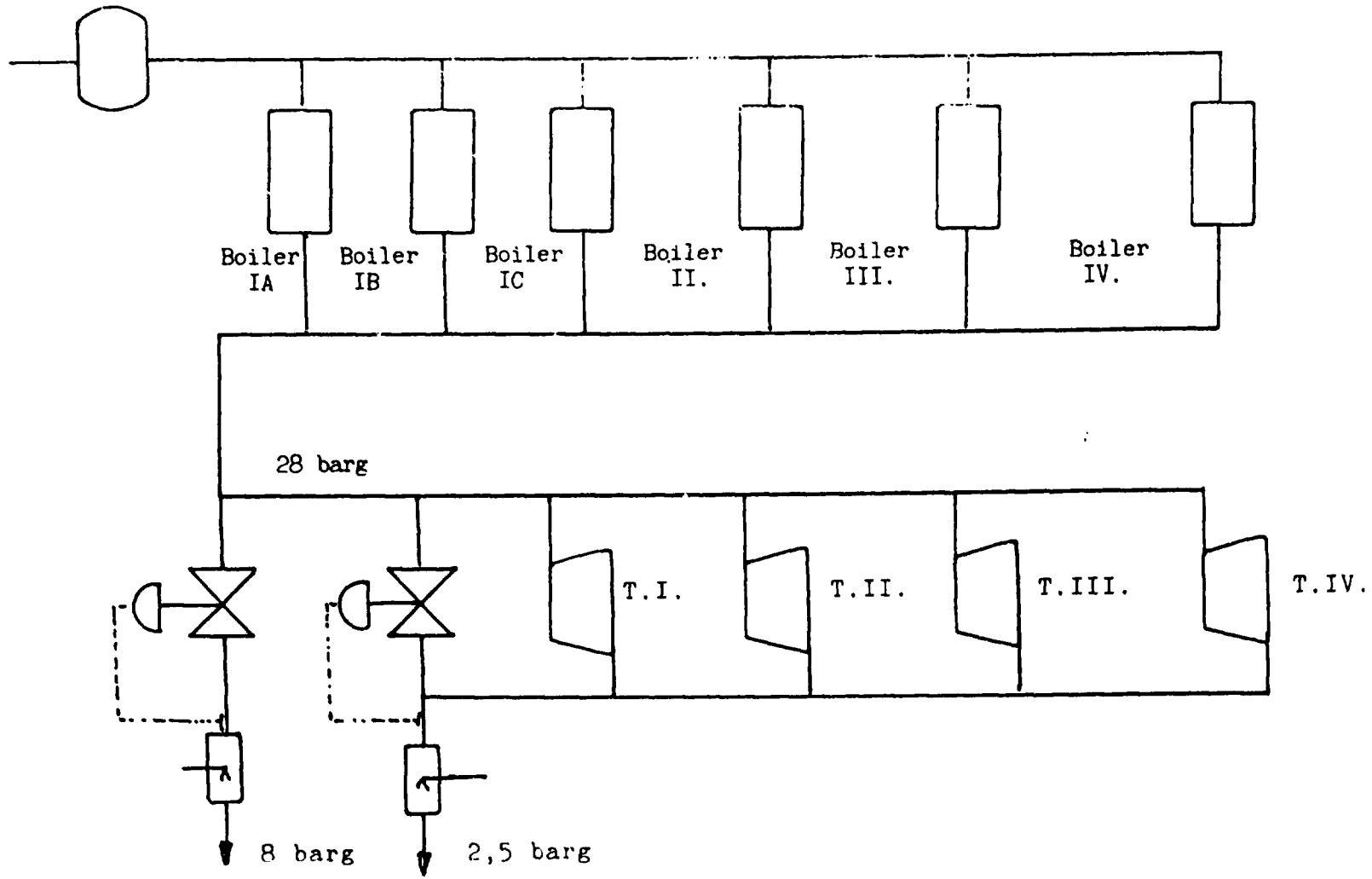
Boiler feed water
Boiler IA
Boiler IB
Boiler IC
Boiler II.
Boiler III.
Boiler IV.
28 barg
T.I.
T.II.
T.III.
T.IV.
8 barg
2,5 barg

FIG. 1

Firing efficiency is very low. The burner nozzles have to be changed because of erosion. The atomisation is very poor. Observing the flame it was seen that the oil drops were reaching the refractory wall and the evaporator tubes and were burning there. The flame is controlled manually.
The viscosity of the oil is too high, and also its sulphur content. On the tubes of the non-operating boilers and also on the removed superheater tubes clear signs of sulfuric corrosion can be seen.

Boiler IV is out of operation. The design capacity is 40-44 tons/hour. It was built in 1983. The acceptance procedures were not successful because of "low capacity" and according to the information given by the plant management the "parties were in dispute".
This boiler is fully automatic, the control system and the mechanical parts are in good condition.

Boiler feed water treatment is not acceptable at all!
Only a cation exchanger is existing. There is no anion exchanger, deareator and mixed-bed ion exchanger. The existing water softening process is not controlled adequately.
The company is recommended urgently to install a complete new water treatment unit. The recommended capacity is min. 50 m^3/hour.

Note: The water leaving evaporator bodies I and II is not acceptable as boiler feed water. Usualy this condensate contains sugar droplets.

One of the possible economic solutions for using the condensate from the evaporators is shown in Fig. 2.
Considering that purchasing a new turbine is also recommended (see later) the configuration shown in Fig. 2. is economic and efficient also from an energetics point of view..

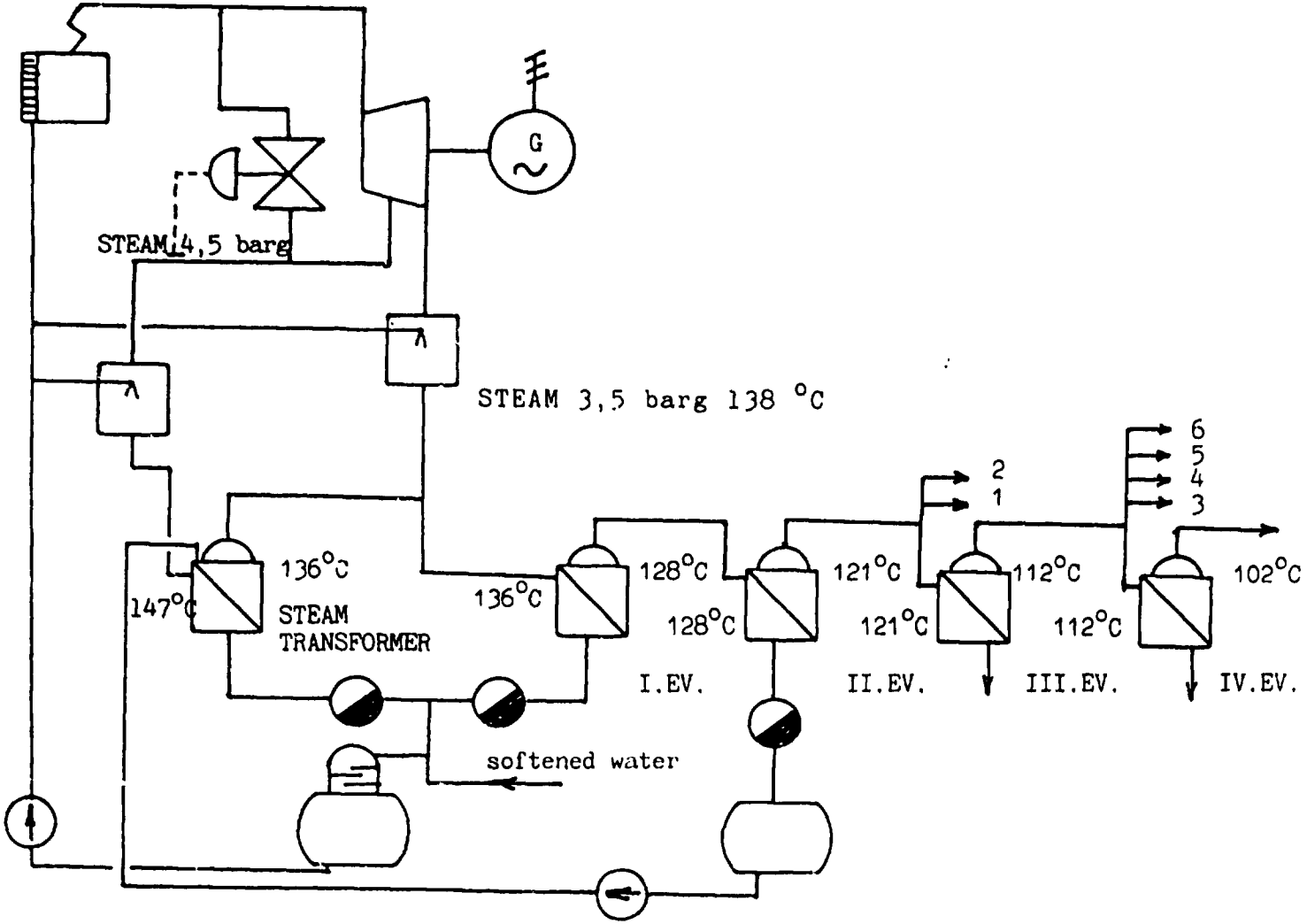
G
STEAM 4,5 barg
STEAM 3,5 barg 138 °C
136°C
147°C
STEAM
TRANSFORMER
136°C
128°C
128°C
121°C
121°C
112°C
112°C
102°C
2
1
6
5
4
3
I.EV.
II.EV.
III.EV.
IV.EV.
softened water

FIG. 2

The back pressure of the turbine would be 2.5–3 barg and a bleeding is to be applied at 3.5–4 barg for heating a steam transformator. The bleeded and back-pressure steam after desuperheating (cooling) enters the steam transformator and the first evaporator. The function of the steam transormator is to re-evaporate the condensate of the first evaporator stage and the fresh water from the "simplified" water softening unit.

After this re-evaporation, these waters are suitable also for high heat-load boilers. The steam from the steam transformator mixed with the desuperheated back-pressure steam of the turbine heats the first evaporator stage.

The higher back-pressure steam gives the possibility to increase the temperatures of the evaporator stages and change the interstage steam bleeding from the first stage evaporator to the second or the third one. For the boiler feed water only the condensates of the steam transformator and the first stage evaporator are suitable.

Even when using this upgraded boiler feed water supply system and evaporator flow diagram it is strongly recommended to control and monitor the sugar pollution, the salt content and the pH value.

The safety valves are to be inspected more frequently also because of possible depositions.

The turbines are operating in "island" condition. In every respect it is more economic to link the turbine driven generators to the electricity system of the country. I have to call the attention of the management to the fact that steam pressure reduction and desuperheating are both theoretically and practically absolutely uneconomical and are to be avoided.

The capacity of turbines I and II is 600 kW with 8–10 tons/hour steam consumption. (Steam flow rates are theoretical values or based on the manufacturer's catalogue.)

Number I is a Skoda turbine (very old construction). There was a rotor change two years ago. In its present condition the turbine would not operate for a long time. The vibration of the machine is too high. There is no vibration monitor for the machine. Due to poor maintenance the rotor is not balanced. The following actions should be taken as a minimum:

- open and clean the machine,
- check the dinamical balancing of the rotor,
- check and adjust the bearings of the machine,
- check and clean the seals of the machine.

Turbine II is relatively new (installed in 1981, ALLEN make) but since the installation there was no maintenance.
The Company is advised to do (out of the campaign period) a complete maintenance in every 3 years as a minimum. During the maintenance the instructions of the manufacturer are to be followed.

Turbine III is ready for operation. A complete maintenance was done under the supervision of the manufacturer (LANG).
The capacity is 1.5 MW and the steam consumption is 18 tons/hour.

Turbine IV is out of order. Considering the condition of the machine it is not worthwhile to investigate possibilities for putting it into operation again. The Company is advised to purchase a new turbine.

The steam consumption and parameters of the units are the following:

- Sugar factory: 35 tons/hour; pressure 2.5 barg; saturated
- Alcohol unit: 2 tons/hour; pressure 8 barg and 2.5 barg
- Cotton seed oil unit: 8-9 tons/hour; pressure 8 barg
- Yeast factory: 2 tons/hour; pressure 1.5 barg

As it is seen, the total consumption for the sugar unit, half of the alcohol unit and the yeast unit approaches the steam consumption of the turbines.
This theoretically means that there is no need to use the reducers between the boiler steam pressure and the 2.5 barg header, however, the steam supply for the users at 8 barg steam pressure level is only possible through reducers.
It is one of the possibilities in case of placing a turbine purchase order to ask for steam bleeding at 8 barg level and also to use this steam to heat the steam transformator mentioned above.
Considering the present status of steam turbines I and IV, this purchase is recommended.

According to the information given by the power plant management the use and control of the turbine oil is not regulated.
It is recommended to control all the turbine oil every year as a minimum and do the necessary treatment (usually cenrifuging.)
Contrary to theoretical possibilities, the pressure of the header and the steam system of the sugar factory is usually 2-2.1 barg. This means that all of the steam used in che company is desuperheated and this is an energy loss.

Approaching the energy supply from the other side: i.e. from electrical point of view, the steam consumption is depending on the load of the turbine (generator) and the steam flow is not controlled following the back pressure (which is equal to the steam header pressure). The back pressure is fixed but not by the steam turbine. It would be much more convenient to fix the back pressure by the turbines and put the surplus electric energy to the central electric system of the country.
This applies also to the other sugar companies becouse all of them are working in "island system".

The steam piping system is very poorly maintained. There are many non-insulated, unnecessary flanges, fittings and valves.

Only for information, a diagram of the heat losses of non-insulated lines is shown Fig. 3.
The Company is recommended to check all steam traced equipment and steam lines and insulate all surfaces operating above 60°C.

For the time being find a short description of the possible procedure to wash the turbines in case of heavy salt deposition:

- unload the turbine
- reduce speed to minimum (500-800 rpm),
- spray clean boiler feed water or light NaOH solution into the steam inlet up to the saturation point,
- open all outlets of the turbine,
- run the turbine under these conditions and check the salt content of outlet condensate.

The steam desuperheater is an absolute energy loss but even more the water injection method is not proper and not controlled.
The Company is recommended to purchase a new in-line water injector instead of the present drum.

The main object of the mission was the energetic analysis of the units.
The poor efficiency is largely due to excessive scaling and through this the reduction of the heat-transfer coefficient.
In the present status it is recommended to carry out a complete chemical cleaning, combined with sodium carbonate and hydrochloric acid boiling. The concentracion of the chemicals is 1-2.5 %.
Between the two boiling steps and after them the evaporators are recommended to be washed out.
During the boiling period the concentration is to be controlled.

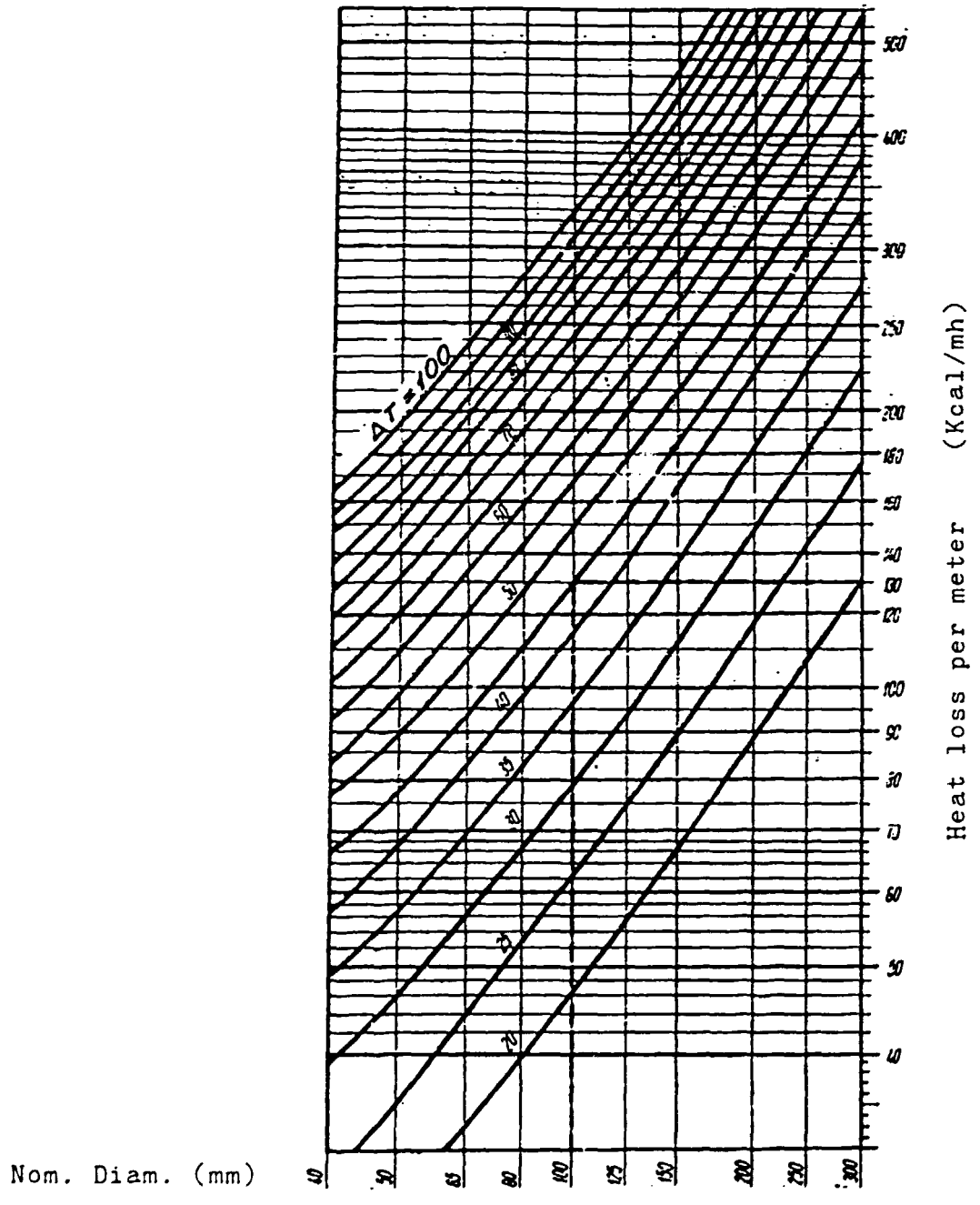

FIG. 3

The maintenance work is not acceptable, first of all the quality is not adequate. The welding procedures and maintenance of the turbines are not proper.
The main reason is the shortage of skilled mechanical workers.

III. TAL SALHAB SUGAR COMPANY

The Company is a relatively new installation (1981).

Design capacity : 4000 tons/day sugar beet
Average effectiveness : 80-90 %
Yield: : 9 %

The unit has three boilers with 32 tons/hour capacity each. The steam parameters are: pressure 32 barg
temperature 380^{o}C

The steam pressure is reduced by two back pressure turbines with a max. capacity of 5.25 MW.
The turbines are working in "island" condition and the electric power consumption of the unit is about 4 MW. Due to this fact the steam flow through the turbines is about 45 tons/hour and the remaining 40 t/hr steam is reduced and desuperheated to provide 2.5 barg saturated steam for meeting other demands in the factory. This is a high amount of energy loss.

The Company is recommended to link the electric power center to the national electricity system (using automatic devices for synchronising and circuit separator for the case of central electric power failure)

The boilers are operating with automatic fuel oil burners, atomising the oil by steam.

The steam superheaters are divided into two sections with intermediate saturated steam injection in order to keep a set outlet steam temperature. One of the main problems is that the tubes of the superheaters are frequently failing (usually after one year of operation).

The first such failure had occured after 4 years of operation.

Since that time the Company has changed the superheaters using tubes with 3 mm wall thickness instead of the original 4 mm.

(The higher wall-thickness tubes were not available.)

Normally using reduced wall-thicnesses for any part of boilers and pressurised vessels is not allowed!!!

The Company is advised to use the types and sizes of materials specified in the design as a minimum!

The main causes for tube failures are as follows:

- Reduced wall thickness.
- The fuel oil contains too much sulphur (more than 7,5 %).
  The Company is advised to blend 20-25 % of gasoil into the fuel oil to reduce the corrosion hazard.
  The vanadium content is also too high in the fuel oil.
- There is a carbon deposit inside the damaged tubes.
  This means that the boiler feed water is not clean enough and probably contains sugar juice. The sugar is baking to the wall inside. The deposit inside the tubes results in the reduction of the heat-transfer coefficient and higher tube temperatures. Gradually the tube burns out and the wall thicness is decreasing first of all at those points where radiant heat transfer is effected. (The wall thickness reduction is 1-1.5 mm at the points of highest radiant heat transfer.)

It is recommended to check the sugar level in boiler feed water regularly. (There are other signs of contamination, too. See the remarks on the back presser turbines.)

- The flame is too long in the boiler and there is a high radiant heat effect at the first tubes of the superheater.
  It is recommended to reduce the length of the flame.

The boiler feed water quality is not acceptable.
There is a low-capacity boiler feed water softening unit for start-up quantity and after the start-up the first and second evaporators' condensate is used as feed water.
The quality is not controlled properly. In addition to the deposition in the superheaters, there is a deposition at the back pressure side of the turbines.
It is recommenmnded analyse this deposition.

In general, the Company is advised to increase the capacity of the water softening unit.

There are some equipment in the Company where the safety devices are not working (for example the safety valve of the first-stage evaporator is fixed). This is not permissible!!!

There is no regular BOILER AND PRESSURE VESSEL INSPECTION.
It is strictly recommended to organise this REGULAR inspection.
(Including the water quality, the maintenance period and pressure test obligation and the inspection of safety devices).

IV. AL GAB SUGAR COMPANY

The Al Gab Sugar Company was erected in 1967 for sugar beet production and raw sugar refining.

The design capacity is 2000 tons beet/day
The effective capacity is 1100 tons/day

The fuel oil consumption is 140 kg fuel oil/ton of beet wich is more than the double of the acceptable consumption.
There are two boilers with 35 tons/hour capacity each and one with 40 tons/hour steam production capacity. The steam parameters are:

pressure	26 barg
temperature	380°C, superheated

The control of the boiler with 40 tons/hour capacity is automatic, the other two are manually controlled. It is obvious that the manually controlled boiler is operating with full capacity and the automatic one is providing the floating quantity, but this means that the two old and lower efficiency boilers are working with full capacity. The efficiency of the new automatic one is also lower than its rating.
The Company is advised to change the burners and the control system of the old boilers for a new automatic one.

The low pressure steam is provided through two back-pressure type turbines with 2 MW capacity each. The turbines are operating in "island" system, which has similar disadvantages as mentioned before.
The Company is advised to link the turbines to the common electricity system of the country similarly to the other units.

It is also recommended to eliminate the direct steam pressure reducing and desuperheating which is a big energy loss.

Due to the fact that the unit was out of operation it was impossible to check the operation of the burners, the atomising and the analysis of the flue gases.

The insulations of the steam lines and the heated equipments are not acceptable. There are a lot of uninsulated lines, fittings, valves and equipment. The estimated energy loss due to the inadequate insulation is 10-15 % of the total energy consumption.
The Company is strongly advised to check during the campaign all the hot surfaces and tubes, and do the necessary insulation work at surface temperatures of 60°C or above.

The steam distrubution is not acceptable and not economic.
Theoretically the evaporators are the center of the heat distribution in a sugar factory.
The theoretical sketch of the evaporators is shown in Fig. 4. The evaporators can operate when the pressure and the temperature are decreasing from the first evaporator to the last one. The evaporated quantity of steam approaches the inlet steam flow. The decreasing of the steam temperature is 0.5-1°C between two bodies.

The steam inlet at the subsequent stages of the evaporator system is:

$$G_1 = G = G_n + \sum_{i=1}^{n-1} Ri$$

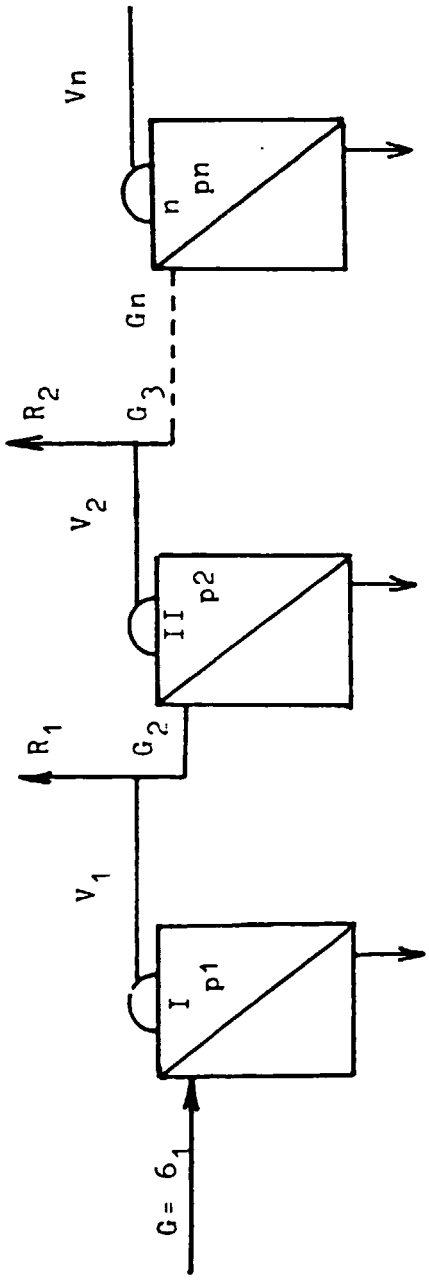

FIG. 4

In the case of four stages:

$$G = G_4 + R_1 + R_2 + R_3$$

where:

G_1; G_2; ... G_n: the heating steam quantity
R_1; R_2; ... R_{n-1}: the bleedings

The other possibility to calculate G is:

$$G = \frac{1}{n}\left(V + \sum_{i=1}^{n-1} (n-1)R\right)$$

where:

$V = V_1 + V_2 + \ldots V_n$: volume of steam produced in each body.

The steam consumption for 100 kg beet would be 43 - 50 kg steam in the case of economic steam distribution.

There are no flow meters at all in the steam system of the unit, but 10-11 items in the process are heated by direct steam, such as the white sugar dryer, centrifuges, lime kiln etc. among others.
This is the main reason of the doubled steam and fuel oil consumption of the Company.

It is recommended to completely revamp the steam distribution system, keeping in mind the following main aspects:

- In each case the lowest temperature steam is to be used for any heating purporse. The steam temperature should be higher by 4-5°C than the highest temperature of the juice in the corresponding equipment. Usually the steam of the III effect is used for refining (or a part of the II effect).

- Reduce or eliminate the steam condensation in the last "condensator" and use this steam for various preheating purposes.

  Use the condensate for purposes where pressurized water is needed.

- Keep in good condition the level controllers of steam heated equipment. (Presently none of them are working.)

- Minimise the direct or live steam consumption.

The typical steam distribution system is shown in Fig. 5.

The most important step is first and foremost to descale the heating equipment of the unit using the procedure described previously.

There is another significant energy loss at the pulp dryer. There is no temperature regulation for the dryed material and the dryer is overheated.

Generally the instrumentation of the unit is very poor.

The standard of maintenance in the unit is very low. There is no regular inspection of the boilers and pressure vessels.

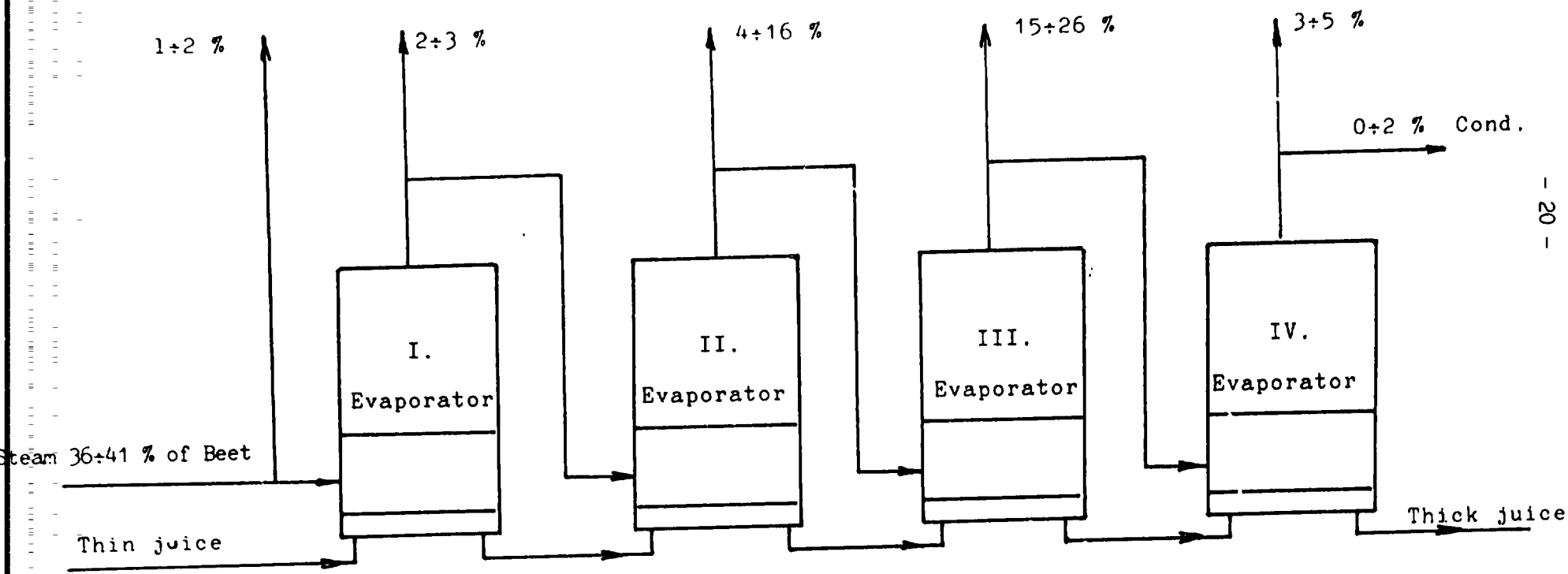
1÷2 %
2÷3 %
4÷16 %
15÷26 %
3÷5 %
0÷2 % Cond.
I.
Evaporator
II.
Evaporator
III.
Evaporator
IV.
Evaporator
Steam 36÷41 % of Beet
Thin juice
Thick juice

FIG. 5

V. HARASTA YEAST FACTORY

The factory was erected in 1959 for wet yeast production.
The design capacity is 7 tons/day wet yeast and the production is 6 tons/day.
There are no significant energetics problems in this unit.

Recommendations:

- Extend the capacity of the plate-type heat exchangers to obtain a better efficiency.
- Check scaling and do the pressure test of the boilers in evry year.
- There are low pressure rating water valves in the steam lines. These are to be replaced with steam valves.
- Inspect and adjust the safety valves every year.
- The safety valves are blowing down inside the boiler house. This is not recommended from labour safety point of view.
- Install a new small boiler feed water softening unit.

VI. GENERAL RECOMMENDATIONS

1. There is neither boiler inspection nor central boiler inspection insitute or authority in the country! The situation is similar with pressure vessels. It is strongly recommended to issue a national boiler and pressure vessel code or standard and also to regulate the inspection system. Till the edition of such a code the Company is advised to issue its own internal procedures, if necessary (on the basis of any similar European code).

2. It is recommended to do a complete revamp at AlGab Sugar Company and upgrade the steam distribution system.

3. Reconsider the incentive system and also the control system for labour discipline.

4. There is no regular education/training for skilled workers and foremen. It is recommended to form a center in each bigger city for this purpose, and first of all in the bigger industrial centers.

Acknowledgements

I wish to express my gratitude to the Syrian Counterparts for their constructive and friendly co-operation, and also for the UNDP Damascus office for their important support.