International Fertilizer Industry Association

IFA Technical Conference

Edmonton, Canada

12-15 September 1988

International Fertilizer Industry Association - Secretariat: 28 rue Marbeuf - 75008 Paris - France
Tel. +33 1 53 93 05 00 - Fax +33 1 53 93 05 45/47 - ifa@fertilizer.org - www.fertilizer.org

STRATEGY FOR SAVING WATER IN A FERTILIZER PLANT SITUATED IN AN ARID REGION WHERE WATER RESOURCES ARE SCARCE AND LIMITED

BENMANSOUR Abderrazak, ESSEBAA Hachemi
(Société Industrielle d'Acide Phosphorique et d'Engrais S.I.A.P.E. TUNISIA).

A - INTRODUCTION

In order to satisfy their water requirements (process water and cooling water), to receive the raw materials and despatch the finished products as cheaply as possible, and to dispose of liquid effluent, industries in general and the fertilizer industry in particular has for a long time set up their factories close to a water source (by the sea or close to rivers).

Tunisia, a major fertilizer producer, is a typical case: since the fifties and until just recently, all the phosphate processing units were built by the sea.

Production costs being favourable, there was no great concern about the growing concentration of factories discharging their gas and liquid effluents into the atmosphere or into the water.

In addition to this, the fact that these factories were situated by the sea, near large towns, meant that they were able to benefit from a specialized labour force and a favourable industrial environment.

It was with the intention of avoiding concentration of factories, moving away from the sea and the urban centres with their increasing complaints about the effects of pollution, that we were led to design, build and operate a phosphate processing unit on an inland site, in a semi-arid region of south Tunisia on the edge of the Sahara not far from the town of GAFSA.

It was not easy at first to sell the idea because, apart from the move away from the urban centres, and the difficulties of procuring energy products, sulphur, and .... the main problem was the quantity and quality of the water.

After several successive technical and economic approaches, nearly all the difficulties inherent in the site were smoothed out; the only remaining unknown factor at the time was how much water was available or could be found in this semi-desert area.

B - EVALUATION OF WATER QUANTITIES AND QUALITIES

First of all, it is interesting to note that the site chosen has a definite advantage, since it borders on a phosphate mine and its washing plant (M'DHILLA Mine 15 kms from GAFSA) which enables the factory to use wet phosphate and thus already offers a saving in water as compared to other factories built away from the mining centres and using dried phosphate.

All the available groundwater resources, which are very limited to provide for the needs of the phosphate washing plants, and of agriculture, were looked at from the point of view of both quality and quantity.

Two qualities of groundwater were finally chosen:

- The first, which we shall call brackish water has the following analysis:

pH	7.7
TA°F	0.00
TAC°F	35
TH°F	273
Cl-	6.141 g/l
Mg++	0.201 g/l
Ca++	0.77 g/l
SO_4--	1.98 g/l
SiO_2	0.038 g/l
Dry extracts	14.163 g/l

- The second quality of water, which we shall call soft water, has the following analysis:

pH	8.1
TA°F	0.00
TAC°F	22.5
TH°F	138
Cl-	0.219 g/l
Mg++	0.99 g/l
Ca++	0.41 g/l
SO_4--	1.42 g/l
SiO_4	0.0155 g/l
Dry extracts	2.722

These two qualities of water will be drawn from two groundwater tables situated at a depth of 200 to 300 m.

As regards quantities, the authorization to drill in these two tables was subject to very close consumption balance analyses: the minimum of water was to be used particularly as regards soft water which was the only source of water for agriculture in the region.

It was, therefore, imperative to study in close detail the quantities and qualities of water available in order to define the phosphate fertilizer product plan to be carried out. This excluded processes and equipment requiring heavy water consumption. It was, for example, out of the question to concentrate phosphoric acid.

C - DEFINITION OF THE PLAN

The plan finally settled on consists of a factory producing 400,000 T of Granulated Supertriple per year. The plan includes:

- A sulphuric acid production line of 1500 T/day
- A phosphoric acid production line of 27-28% P_2O_5 with a capacity of 480 T/day of P_2O_5.
- Two TSP production lines operating on 28-30% P_2O_5 dilute acid with a capacity of 675 T/day each.

The factory's auxiliary plants include:

- A 15 MW turbo-generator
- A 15 T/H auxiliary boiler

- A 15 T/H distillation and desalting plant
- A compressed air plant
- Water, acid and fuel oil storage tanks
- Mechanical, electrical and instrumentation repair shops etc ....

It should be noted that, in addition to the restrictions on quantities of water, it was necessary to apply the regulations for combating pollution by gas, liquid and solid waste.

1/ - Soft water balance

The soft water balance is considered in two forms: operation at the nominal rate and at 110% of the nominal rate. This balance includes:

- In the sulphuric shop: dilution water estimated at 11 m3/h.

- In the utilities: water intended for distillation and production of boiler supply water. Boiler water requirements were 15 m3/h, and 55 m3/h of soft water have been reserved for this distillation. The brine from the distillation will be recycled in the cooling water.

- In the phosphoric acid shop: the soft water intended for supply of the phosphoric shop is made up of process water proper (150 m3/h), water for the supply of the liquid ring vacuum pumps and coolant for the linings of slush pumps and other pumps. The necessary flow is estimated at 180 m3/h.

- In the TSP shop: soft water is used in the TSP units to cool the oil lubricating the phosphate grinder bearings and the pump linings. This quantity is estimated at 20 m3/h.

We would point out that the consumption forecasts for soft water at the planning stage are estimated at 276 m3/h, with the factory operating at the nominal rate of production (see table 1).

ESTIMATED SOFT WATER REQUIREMENTS

Table 1

SHOP	REQUIREMENTS AT NOMINAL RATE m3/h	REQUIREMENTS AT 110% - m3/h
Sulphuric	11	12
Utilities	55	55
Phosphoric	180	200
T.S.P	20	20
General services	10	10
TOTAL	276 m3/h	297 m3/h

2/ - Brackish water balance

The consumption forecasts for brackish water are made up of evaporation from the cooling towers and extractions from the basins of this tower, being 285 m3/h. The evaporated water is estimated at an average 135 m3/h.

The extractions are used to meet the water requirements for gas purifying in the phosphoric and TSP shops. On leaving the washers, this water is used to repulp the gypsum phosphate.

The water recovered after decantation of the gypsum phosphate is used as a top-up for the repulping of the gypsum.

These requirements are estimated as follows:

- Phosphoric shop : 50 m3/h
- TSP unit : 100 m3/h
- Gypsum repulping : 200 m3/h
- Recovery after decantation of the gypsum phosphate : 50 m3/h

ESTIMATED BRACKISH WATER REQUIREMENTS

Table 2

SHOP	REQUIREMENT AT NOMINAL RATE m3	REQUIREMENT AT 110% m3
Sulphuric		
Utilities	135	150
Phosphoric	50	55
T.S.P.	100	110
TOTAL	285 m3	315 m3

D - DESIGN OF THE WATER DISTRIBUTION

It was difficult to obtain the quantities of water estimated above. For this reason we designed water circuits adapted to the circumstances:

- Use of a cooling tower with fresh water top-up and extraction to maintain an acceptable salt content.
- Recovery of water at every possible stage.
- Recycling of water as thoroughly as possible.

The total theoretical quantity of water at our disposal is 145 l/s (520 m3/h).

- 80 l/s of soft water (288 m3/h)
- 65 l/s of brackish water (234 m3/h)

While the 65 l/s of brackish water was real, since drilling had already taken place, the quantity of soft water was less accessible as it had to be sought at a depth of 200 to 250 metres and, in the past, the phosphate washing plants located in the region for more than 50 years had come up against the problems of water catchment in this region where the subsoil is sandy and the water tables unpredictable.

Among the choices made, the equipment had to be low on water consumption and undemanding as to the quality of the water: we therefore opted for:

- An air condenser for the condensation of steam during stoppages of the turbo-generator or a reduction in its output.
- Use of a scoop filter of suitable design: dry discharge filter and repulping of the gypsum phosphate

in brackish water and washing of the nets in soft water, with re-use of the washing water as process water.

- Recovery and recycling of everything which is cooling water.

1/ - Soft water or process water circuit
(See diagrams "a" and "b")

The "soft" water drilling area is situated 10 kms from the factory. The drilling carried out discharges into a 100 m3 reservoir serving as a tank for a pumping station which supplies a 5000 m3 soft water reservoir in the factory. This reservoir serves as an equalising reservoir for the distribution of the water. 1/3 of its volume is reserved for the "fire water" circuit.

Diagram "a" represents the soft water collected outside the factory. Diagram "b" represents the distribution of this water inside the factory.

PATH OF SOFT WATER OUTSIDE THE I.C.G FACTORY

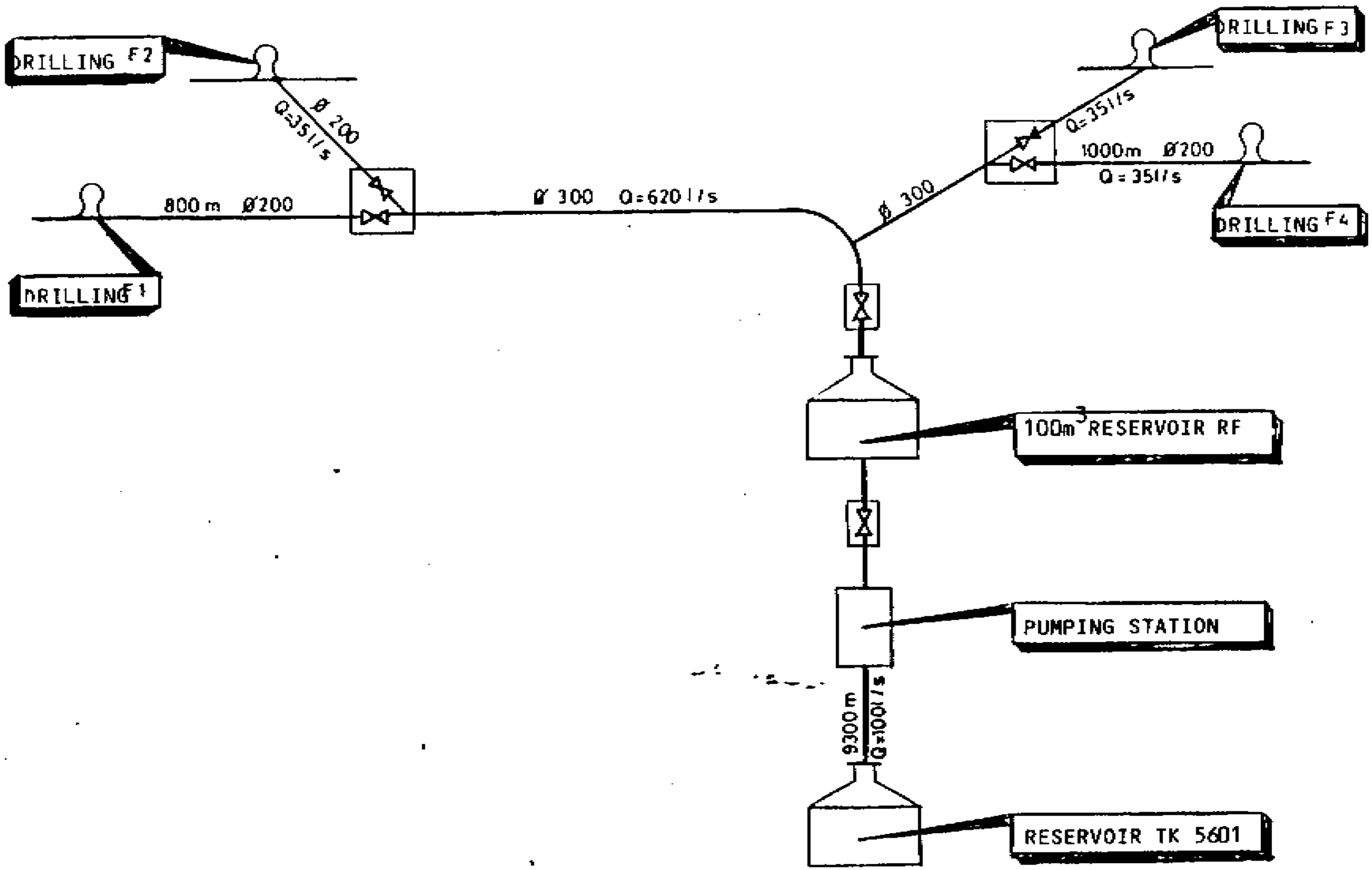


DIAGRAM (a)

DISTRIBUTION OF PROCESS (SOFT) WATER OF THE I.C.G FERTILIZER PLANT

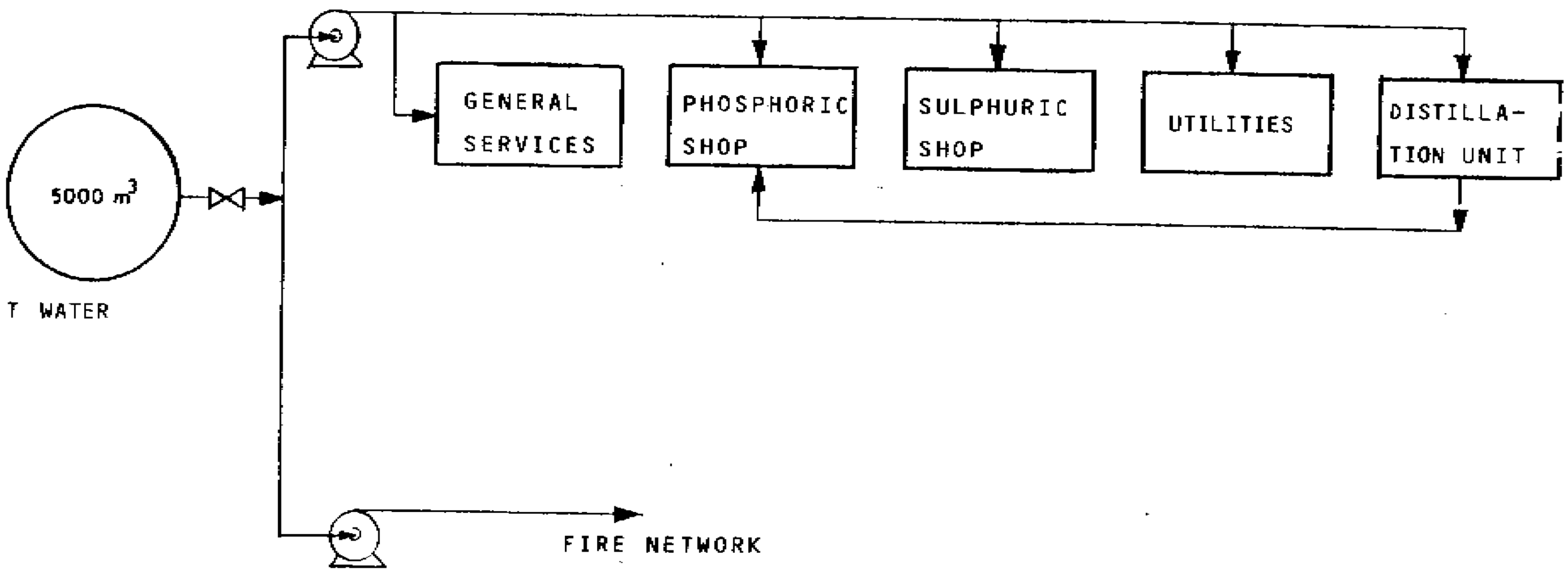


DIAGRAM (b)

2/ - Circuit of brackish water for cooling and gas purification

The water obtained from drilling the brackish water table is fed by gravity to the factory. It passes through a 5000 m3 equalising reservoir (see diagram C).

The cooling water circulates in a closed loop. Starting from the equalising reservoir it runs in the following circuit:

- The tanks of the cooling tower
- The cooling apparatus
- The cooling tower
- then the tanks again ...

The cooling tower is a forced air circulation tower enabling 80,000 "thermies"/h to be evacuated.

This cooling tower and its tank are divided into two parts:

- One part cooling the water from the condensers and the cooling apparatus for the utilities and the turbo-blower.

- The other part cooling the sulphuric acid coolants. This water must on no account be mixed with the water of the first part.

This arrangement was chosen in order to protect the condensers and the utilities cooling apparatus from the risks of possible piercing by sulphuric acid coolants.

In order to avoid excessive concentrations of salt in the recycled water, extractions of water are taken from the half tanks of the tower. These extractions are used in the washing towers of the phosphoric and T.S.P. shops (see analysis of the waters of the tower).

The purifying of the gases of the TSP units is done in two stages: the first washing is done with phosphoric acid and the second with brackish water.

This combination of two washes, the first in phosphoric acid and the second in water, allows us to comply with the regulations for the protection of the environment, to minimize water consumption in gas purifying and to recover the dust carrying P_2O_5.

Diagram (d) represents the brackish water network for cooling, gas purifying and repulping of gypsum inside the factory.

Everything described here is merely a design of things in the context of the plan. In reality, after the factory was built, the drilling for water begun and the production units put into operation, we had to face other difficulties which, even though they had been foreseen, proved difficult to resolve. We had to adapt to the real situation and find the necessary solution.

PATH OF BRACKISH WATER OUTSIDE THE I.C.G FACTORY

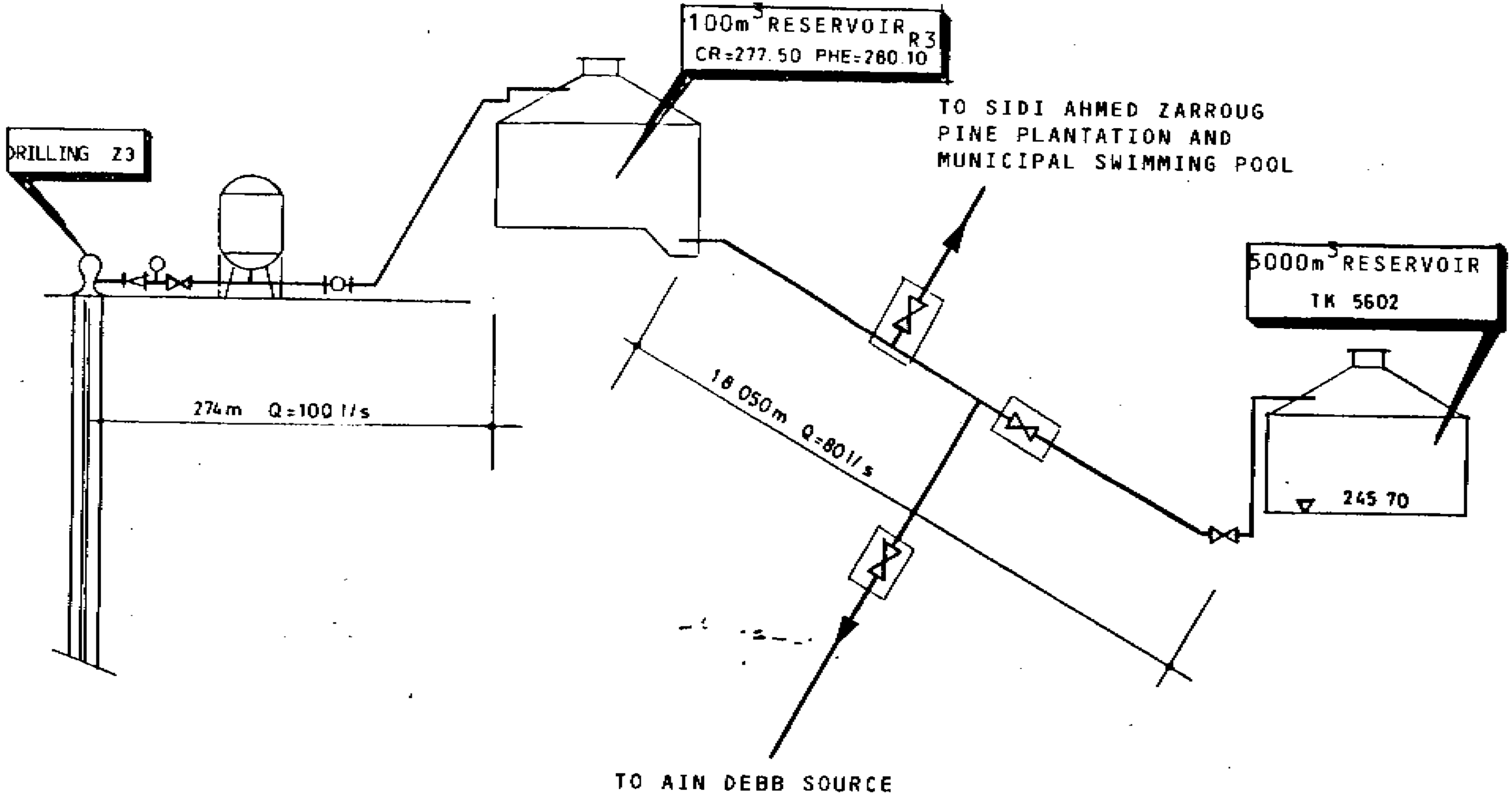


DIAGRAM (c)

DISTRIBUTION OF COOLING AND WASHING WATERS OF THE I.C.G FERTILIZER PLANT

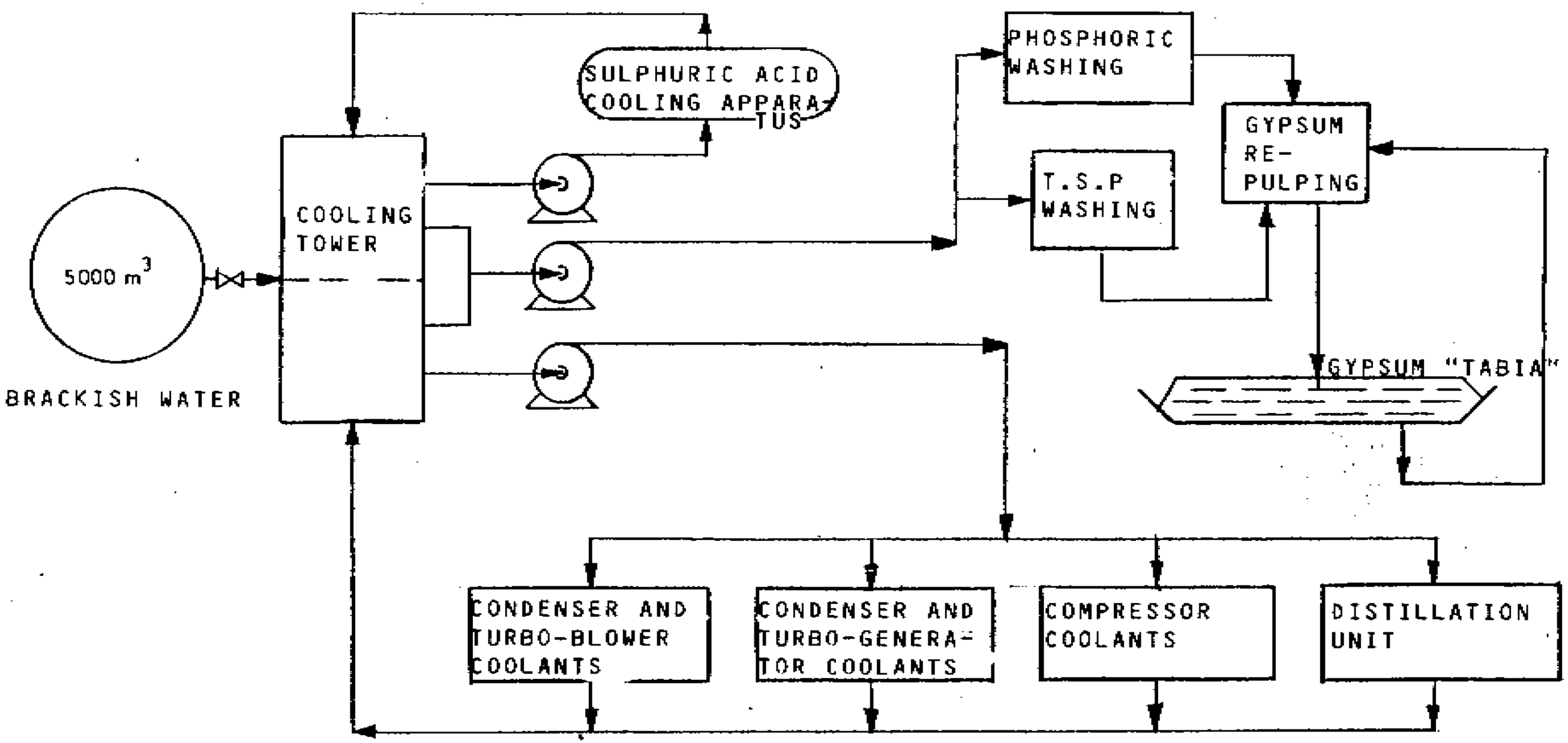


DIAGRAM (d)

E - OPERATION OF THE FACTORY

On start-up of the factory and after a few months of operation several problems arose, due mainly to water, and each time solutions had to be found which would enable the factory to produce under the best conditions of price and quality.

Among the most serious difficulties due to water problems are:

- The quantity of soft water provided is not in keeping with the forecasts. The drillings carried out did not meet the requirements and yields continued to drop before stabilizing after six months of operation at values of around 50 to 60% of forecasts.

- The brackish water provided for cooling flows at a constant rate but behaves in the cooling circuits in such a way that the heavy incrustations which it produces bring about a fall in heat exchange, leading to reductions in production capacity.

Repeated mechanical and chemical cleaning operations are carried out, but these become less effective each time. Although the utilities coolants behave after a fashion, the sulphuric ones are more sensitive and have become the bottleneck of the whole factory.

The decantation of gypsum phosphate is also complicated as the quantity of water recovered at the start is insignificant. The large area of storage of gypsum phosphate, the very dry climate of the region, and the earth which has not been waterproofed have meant that, during the first few months, recovery by decantation of the gypsum phosphate waters has been practically nil.

How to solve these problems

Firstly, as regards the insufficient process water, the choice is difficult and immediate solutions had to be found:

1/ - The distillation to produce boiler water based initially on soft water has been replaced by the distillation of brackish water, at the cost of further chemical treatment and some operating difficulties.

2/ - It was necessary to recover any quantity of soft water used such as:

- the water of the liquid ring of the vacuum pumps.

- cooling water of the linings of the pumps, grinder bearings, etc ....

- the use of general services has been reduced to a bare minimum.

3/ - We have been forced several times to top up soft water with brackish water within a certain limit. The drawback of the chlorine content of the water, which is almost forgotten, enabled the factory to operate. The chlorine content of the water, fixed by experiment for the treatment of Gafsa phosphates at 1100 ppm, rose to 1800 to 2000 ppm without excessive corrosion of the equipment: pumps, agitator, filters, etc....

As regards the cooling water, solving the problem was laborious although the quantity of water expected is available. Incrustations on the exchangers are such that several approaches have been devised:

1/ - In order to minimize incrustations, extractions from the cooling tower have been increased. However, this solution has the disadvantage that more cooling water is required, and this requirement is difficult to meet.

2/ - Chemical treatment of the water, which at the beginning was standard, depends greatly upon the quality and quantity of water available. In a few months, and after repeated tests with different chemical products, the technico-economic approach was perfected.

Since then, the sulphuric acid exchangers operate normally thanks to strict controls on the salt concentration in the waters of the cooling tower.

With all the corrections made to the consumption forecasts for soft water, and to the treatment and recycling of brackish water, we were able to meet the factory's needs with the following quantities at the nominal rate of production.

- Soft water : 165 m3/h ~ 46 l/s
- Brackish water: 285 m3/h ~ 80 l/s;

the real balances are illustrated in tables (3) and (4).

REAL BALANCE OF THE CONSUMPTION OF SOFT WA"ER

Table (3)

	Nominal yeild m3/h	Rate of activity	Average yield m3/h	Average annual yield m3/h
Sulphuric	11	0.98	10.8	9.8
Utilities	0		0	0
Phosphoric phosphate re-pulping	37	0.92	34	31
Phosphoric filtration	112	0.95	106	96
T.S.P	0		0	0
General services	5		5	5
TOTAL	165		155.8	141.8

- Utilities: Following the unexpected deficiency in yields of the drillings for soft water, production of boiler water is achieved using brackish water.
- Phosphoric: The use of wet phosphate necessitates the preparation of a 65% solid pulp. The flow of water necessary for this repulping is 37 m3/h. This water is deducted from the water sent through the filter. The 112 m3/h representing the water requirements for washing the filter nets are entirely recovered to be used as process water. The waters from the vacuum pumps and pump linings are recovered and included in the 112 m3/h.
- T.S.P. : The soft water used for cooling the grinder bearing lubricating oil and for lubrication of the pump linings are recovered and reused.

REAL BALANCE OF THE CONSUMPTION OF BRACKISH WATER

Table (4)

SHOP	NOMINAL YIELD m3/h	RATE OF ACTIVITY	AVERAGE YIELD m3/h	AVERAGE ANNUAL YIELD m3/h
Sulphuric	50	0.98	49	44
Utilities				
cooling tower	70	0.95	66.5	60
Distillation	15	0.7	10.5	9.5
Phosphoric	50	0.92	46	42
T.S.P.	100	0.90	90	81
TOTAL	285	-	262	236.5

Sulphuric : 50 m3/h represent evaporation in the part of the cooling tower allocated to the waters from the sulphuric acid cooling apparatus.

Utilities : 70 m3/h correspond to evaporation in the second part of the tower used for cooling waters from the condensers and cooling apparatus for the utilities and the turbo-blower.

T.S.P. and phosphoric shops: The brackish water used is made up of water extracted from the tanks of the cooling tower and represents approximately 150 m3/h.

F/ - RESULTS AND CONCLUSIONS

Started in May 1985, and after all the ups and downs described above, the factory reached its cruising speed in the first few months of 1986.

This production reached 420,000 T. in 1987 and we believe that this peak in production will be exceeded given that the Sulphuric Unit is oversized in relation to the requirements of the basic 400,000 T/year.

These results have been made possible by a continuous search for appropriate solutions to the problems which have arisen.

It goes without saying that while solving the problem of concentration of factories on the coast, we have been able to design and put into operation a fertilizer plant which complies with the regulations in force for the protection of the environment.

In order to carry out such a project, however, in conditions similar or identical to those of our GAFSA factory and to have the best chance of succeeding we feel that the most important points to consider are the following:

1/ - Wise choices of manufacturing processes. In our case the processes chosen are the SIAPE phosphoric acid production process and the SIAPE T.S.P. production process.

2/ - Choice of equipment.

3/ - Optimization of design of units using water.

4/ - Promoting an awareness in all those involved at the stages of research, production and operation, of the need to save water.

APPENDICES

A-1- DIAGRAM OF THE DISTRIBUTION OF WATER TO THE PHOSPHORIC SHOP

A-2- DIAGRAM OF GAS PURIFICATION OF THE T.S.P. SHOP

A-3- CHEMICAL ANALYSIS OF SOFT WATER

A-4- CHEMICAL ANALYSIS OF BRACKISH WATER

A-5- CHEMICAL ANALYSIS OF WATER IN THE COOLING TOWERS OF THE SULPHURIC ACID COOLING APPARATUS

A-6- CHEMICAL ANALYSIS OF WATER IN THE COOLING TOWERS OF THE TURBINE CONDENSERS AND UTILITIES

A-7- CHEMICAL ANALYSIS OF WATER RECOVERED FROM THE GYPSUM PHOSPHATE STORE

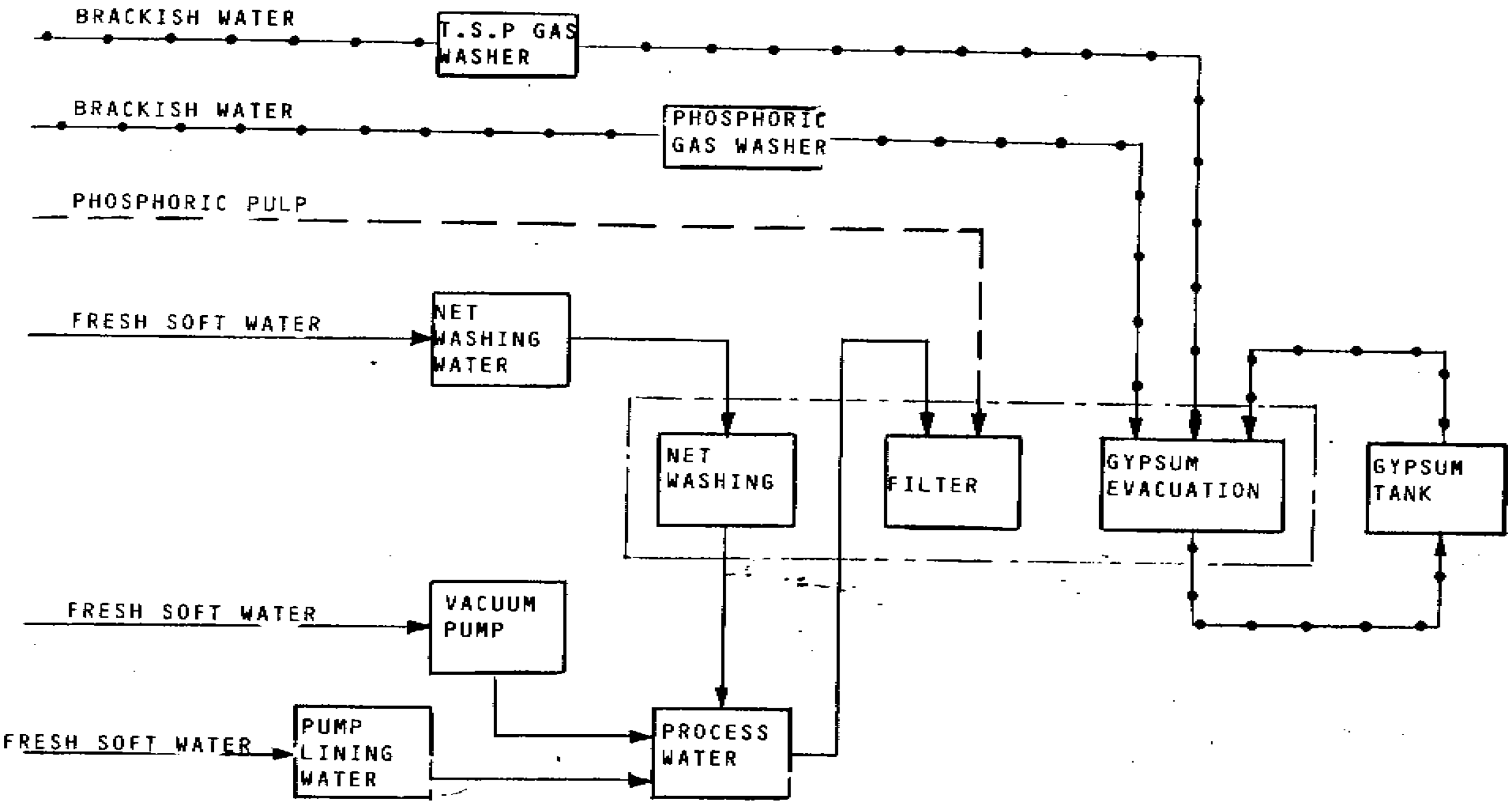
A-8- AVERAGE CHEMICAL ANALYSIS OF THE PHOSPHATE USED

A-9- AVERAGE CHEMICAL ANALYSIS OF THE TSP PRODUCED (FRESH)

A-10- AVERAGE ANALYSIS OF SALEABLE T.S.P.

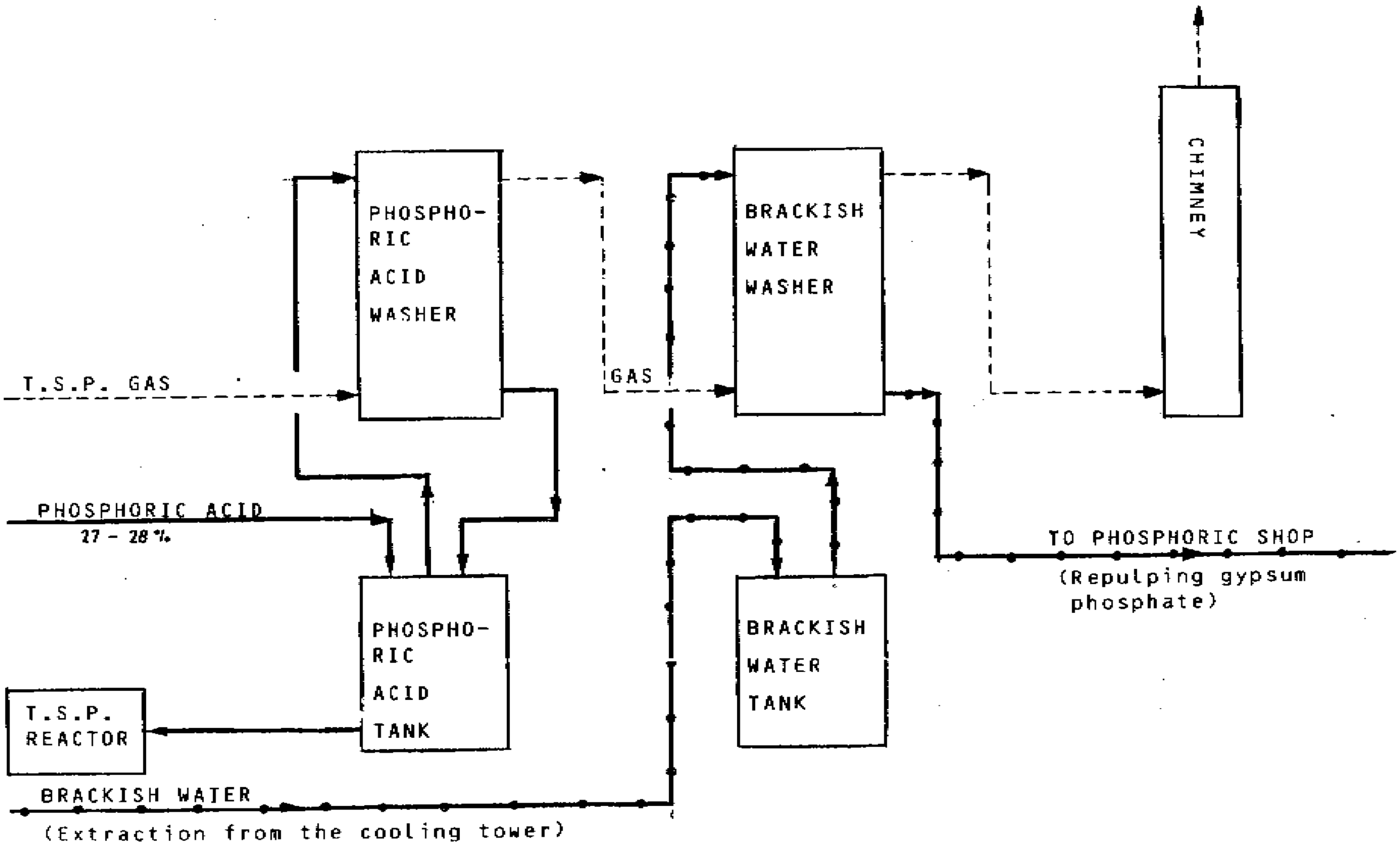
A-11- MONTHLY PRODUCTION OF I.C.G. TSP FOR 1987

DIAGRAM OF THE DISTRIBUTION OF WATER TO THE PHOSPHORIC SHOP



APPENDIX 1

DIAGRAM OF GAS PURIFICATION OF THE T.S.P. SHOP



APPENDIX 2

A-3-

ANALYSIS OF SOFT WATER

pH	- 8.1
TA°F	- 0
TAC°F	- 22.5
TH°F	- 138
Cl-	- 0.219 g/l
Mg++	- 0.99 g/l
Ca++	- 0.41 g/l
SO_4--	- 1.42
SiO_2	- 0.0155 g/l
Dry extracts	- 2.722 g/l

A-4-

ANALYSIS OF BRACKISH WATER

pH	- 7.7
TA°F	- 0
TAC°F	- 35
TH°F	- 273
Cl-	- 6.141 g/l
Mg++	- 0.201 g/l
Ca++	- 0.77 g/l
SO_4--	- 1.98 g/l
SiO_2	- 0.038 g/l
Dry extracts	- 14.163

A-5-

ANALYSIS OF WATER IN THE COOLING TOWER OF THE SULPHURIC ACID COOLING APPARATUS

pH	- 8.2
TA°F	- 5
TAC°F	- 40
TH°F	- 350
Cl-	- 8.010
Mg++	- 0.27
Ca++	- 0.99
SO_4--	- 2.50
SiO_2	- 0.0086
Dry extracts	- 18.070

A-6-

ANALYSIS OF WATER IN THE COOLING TOWER OF THE TURBINE CONDENSERS AND UTILITIES

pH	- 8.3
TA°F	- 5
TAC°F	- 42.5
TH°F	- 382
Cl-	- 7.768
Mg++	- 0.28
Ca++	- 1.06
SO_4--	- 2.77
SiO_2	- 0.001
Dry extracts	- 17.99

A-7-

ANALYSIS OF WATER RECOVERED FROM THE GYPSUM PHOSPHATE STORE

pH	- 1.7
TA°F	- 0
TAC°F	- 0.00
TH°F	- 494
Cl^-	- 6.797 g/l
Mg^{++}	- 0.35
Ca^{++}	- 1.36
SO_4^{--}	- 6.88
P_2O_5	- 2.58
SiO_2	- 0.120 g/l
F	- 2.30 g/l
Solid materials	- 0.32%
Organic materials	- 0.093%
Dry extracts	- 21.52 g/l

A-8-

AVERAGE ANALYSIS OF THE PHOSPHATE USED

P_2O_5	28.81%
CaO	49.16
MgO	0.62
SiO_2	3.23
F	3.31
SO_3	3.67
CO_2	6.87
Chlorine	0.11
Fe_2O_3	0.30
Al_2O_3	0.64
Organic materials	1.27

A-9-

AVERAGE ANALYSIS OF T.S.P. PRODUCED (FRESH)

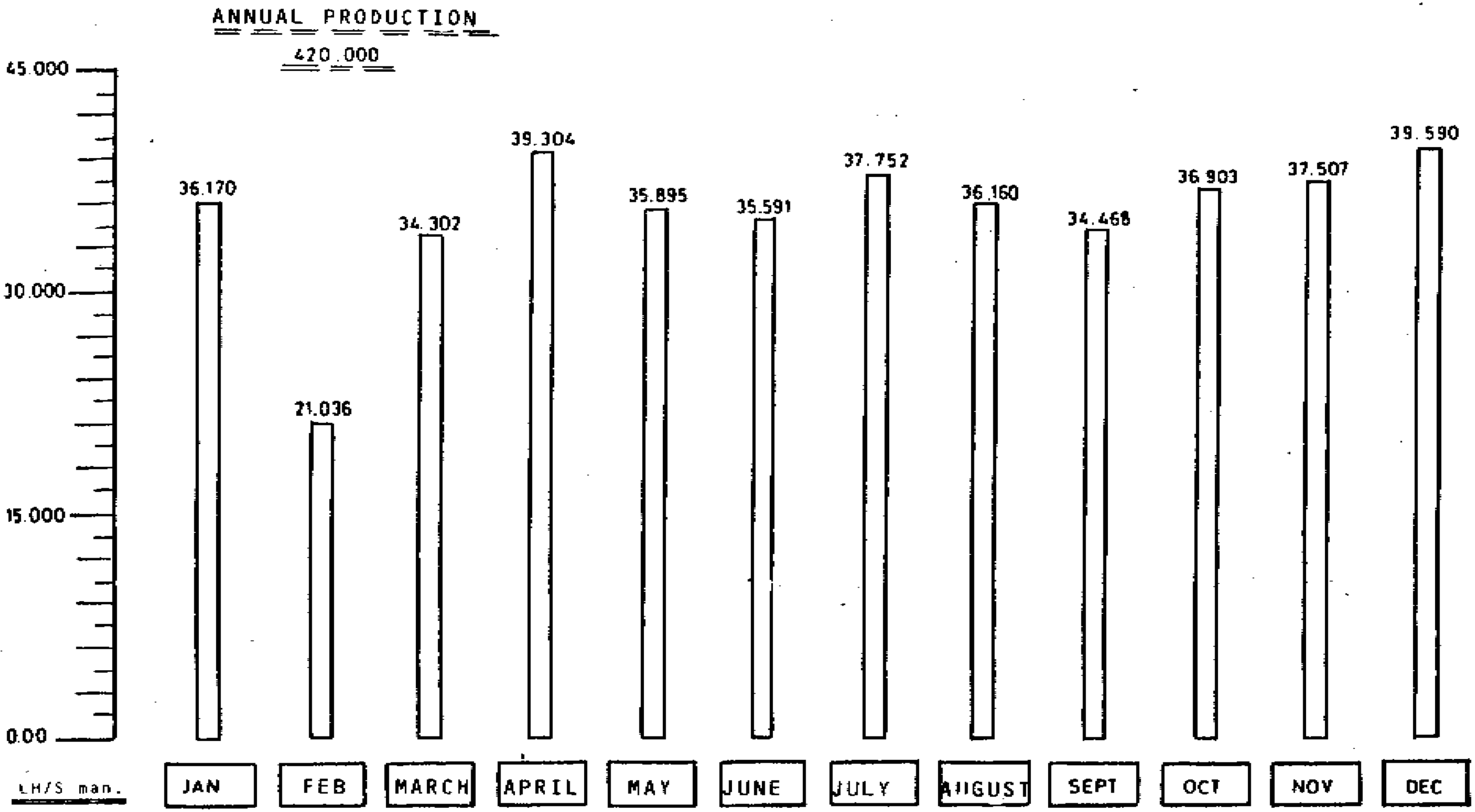
P_2O_5	46.55
CaO	20.96
MgO	1.01
SiO_2	1.89
F	2.20
SO_3	3.06
Chlorine	0.30
Fe_2O_3	0.37
Al_2O_3	1.01
Organic materials	0.50
Losses at 1000°C	28.08
H_2O	6.19

A-10-

AVERAGE ANALYSIS OF THE SALEABLE T.S.P.

Total P_2O_5	47.72
APA P_2O_5	46.74
Water soluble P_2O_5	43.15
Free acidity	3.96
Humidity	3.80

MONTHLY PRODUCTION OF T.S.P OF THE I.C.G FACTORY
FOR THE YEAR 1987



APPENDIX 11

TA/88/20 Strategy for saving water in a fertilizer plant situated in an arid region where water resources are scarce and limited by A. Benmansour and H. Essebaa, SIAPE, Tunisia.

DISCUSSION (Rapporteur Mr. A. Davister, Prayon, Belgium).

Q - Mr. P. ORPHANIDES (Duetag, France)

1/ Have you investigated the possibility of reducing cooling water requirements by utilizing the absorption heat in your sulphuric acid plant for boiler feed water heating or for phosacid evaporation ?

2/ Did you re-evaluate that possibility later on ?

3/ Water is a very rare and useful commodity in desertic areas. Other people should be able to use it, for instance farmers. What is your opinion ?

Is it good or not to have accepted the pressure of local authorities to install your plant far from the sea and in a desertic area ?

A - 1/ No, we did not, as the supply of water was expected to be satisfactory. It is only after the start-up that we had those difficulties that reduced the water suply.

2/ No, we did not do it.

3/ An official state organization is controlling and regulating the use of water resources. We have complied with their rules and have been controlled constantly.

Yes, we have followed the opinion of the ecologists when we decided to install the ICG plant in a desertic area, but we are satisfied with our decision. It has led to some savings, and now the average cost price is lower than the cost price obtained in our factories located on the sea-side.

Q - Mr. T. KOIVUMAKI (Kemira Oy, Finland)

1/ You have used cooling towers to cool the recycled water and these evaporate 135 m3/h of water. Why do you not use cooling systems that do not evaporate water like air cooling or ammonia or freon ?

Is it a question of investment cost ?

A - Before building the plant, we studied air cooling, but the size of the air-cooled exchangers would have been like a football ground and the cost was of course excessive.

As far as ammonia is concerned, we do not use ammonia on that site.

Q - Mr. P. BECKER (Duetag, France)

1/ What was, approximately, the increase of that corrosion rate due to the mixing of brackish water with fresh water and the resulting increase in chloride content ?

2/ What is the type of soil where you made your gypsum pile ? Have you any idea of water evaporation and leaching ? Did you use any means

.../.../...

to make your pond impervious ?

A - 1/ SIAPE operates with a level of chloride in the range of 1100 ppm. In ICG, even with the current mix of water, the chloride level is lower, in fact less than half the SIAPE level. Of course, exceptionally and only to avoid a shut-down of the plant, we have used quantities of brackish water bringing the chlorine level up to 2000 ppm, but this was for very short periods and we have not measured the corrosion rates at those periods.

2/ We did not use any artificial process to make the soil impervious, and during the first months, all the water was leached into the soil, but after a while, the gypsum itself has become impervious and we have been able to recover and recycle water that is used to pulp the gypsum. This is a self sealing procedure.