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COMPACTED FERTILISERS

by

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(S.A.P.E.C. - Produits et Engrais Chimiques du Portugal

INTRODUCTION

The purpose of this paper is to make the experience gained by S.A.P.E.C. - Produits et Engrais Chimiques du Portugal, S.A., in the field of compacted fertilisers generally available.

After a summary of tests carried out in the laboratory and in a pilot plant, a production plant, constructed in Portugal, is described, with some manufacturing data and giving details of some applications of the compacted fertilisers.

Finally, some observations of an economic nature will be made.

THE ROLE OF S.A.P.E.C. IN THE PORTUGUESE FERTILISER MARKET

1. S.A.P.E.C. is a Belgian company, having its registered office in Brussels and being active in Portugal in the following industrial fields:

   - mining (pyrites mines);
   - metallurgy (production of hard metal);
   - production of fertilisers, pesticides and feeding stuss.

   The fertiliser division includes the following products:

   - sulphuric acid;
   - phosphoric acid;
   - superphosphates;
   - ammonium sulphate;
   - diammonium phosphate (20-50);
   - NPK compound fertilisers.

2. The fertiliser market in Portugal:

Portuguese agriculture which has to solve serious structural problems has extremely low consumption levels for fertilisers, in comparison with the average for European countries; they are even lower than those of the countries of Southern Europe with similar climatic conditions.

This is therefore a small fertiliser market, compared with those of countries having a similar actual agricultural area.

Production of fertilisers has been undertaken since 1977 by two concerns:

- QUIMIGAL (a public corporation covering 80% of the entire market and 70% of the market shared by the two concerns);
- S.A.P.E.C. (a private company which does not produce nitrate fertilisers).

3. The position of S.A.P.E.C. in the export market:

The small size of the home market in comparison with its production capacity drives Portugal into exports and into holding a fair position as fertiliser exporter in the world market, when compared with other European countries.

The export business of S.A.P.E.C., especially in the compound fertiliser field, is not negligible, not so much in quantity as in quality.

Overall, it can be said that the production of S.A.P.E.C. is distributed as follows:

40% to the export market,
60% to the home market.

4. Outlook for development:

In view of the low rate of development of the home market in the direction of qualitative transformation (higher growth in concentrated granular fertilisers) and the strengthening of the export market, S.A.P.E.C. decided to increase its production capacity for compound fertilisers so as to reach:

- an increase of from 60,000 to 80,000 t/year in its capacity, with the possibility of producing concentrated fertilisers;
- interchangeability in production between NP and NPK fertilisers;
- adaptation to the raw materials and intermediate products available;
- the lowest possible investment cost.

COMPOUND FERTILISER PRODUCTION METHODS

In Portugal, as in fact in the other European countries, compound fertilisers are used, above all, in solid form.

Production methods, as it is known, depend upon the raw materials used and may be summarised as follows:

1. Granulation of a solid mixture with steam/water:

   A previously prepared mixture of products such as SSP, TSP, ammonium sulphate and potassium chloride, can be granulated with steam/water.

2. Granulation of a solid mixture with acids (sulphuric/ phosphoric) and ammonia:

   The heat released by the neutralisation of the acids makes a marked reduction of water possible.

3. Granulation of a slurry:

   In this process, most, if not all, the raw materials are supplied in liquid form.

   The slurry to be granulated derives from the reaction of ammonia with sulphuric, nitric and phosphoric acids.

   Potassium salts and, at times, rock phosphate are introduced occasionally.

   A proportion of the finished granules is recycled so as to maintain the necessary ratio of the liquid phases to the solid phases in the granulator.

The "Spherodizer" method belongs to this type of granulation.

4. Melt granulation:

In this method, the exothermic nature of the reactions involving the neutralisation of sulphuric, phosphoric and nitric acids by ammonia is utilised so as to obtain a water-free melt, which reduces the cost of the drying operation and of the equipment.

Granules can be obtained from the melt, for example, by prilling, on a granulating plate, a granulating cylinder or in a pug mill.

5. Bulk blending:

This consists in mixing mechanically already granulated products. This method is very widely used in the United States.

6. Compacting:

This method was very widely used originally for granulating potassium chloride.

The experience gained by S.A.P.E.C. in compacting compound NP, NPK and ammonium sulphate fertilisers is the subject of this paper.

GENERAL CONSIDERATIONS ON COMPACTING FERTILISERS

1. Principles:

Agglomeration of the finished products is feasible by the application of high pressures, enabling a bond of molecular character to be formed between the different particles, - van der Waals' forces, - adsorption forces, mechanical bonds etc.

The centre-point of the operation is the compactor, consisting essentially of two rollers rotating in opposite directions, one being stationary and the other mobile; the feeding system consists generally of an endless screw which forces the product into the compactor.

A hydraulic system supplies the pressure required for compacting.

The compacted material is then reduced to the dimensions required by the user by a milling operation and associated classification.

2. Determining variables:

The raw materials used and the composition of the mixture are the main factors in obtaining a granular product having the required physical properties. Some materials which can be compacted on their own have a different behaviour, once they are mixed.

Potassium chloride, ammonium sulphate and urea are the products having the best compacting properties.

SSP, calcium cyanamide, Colemanite and rock phosphates, while capable of being compacted, do not have such good properties.

Other important variables affecting the finished product:

Raw materials:

- particle size distribution;
- moisture;
- temperature;
- plasticity;
- hardness.

Working conditions:

- pressure;
- external surface of the rollers;
- diameter and speed of the rollers;
- distance between rollers.

PRELIMINARY COMPACTING STUDIES

With a view to studying the technical possibilities of compacting in the field of the NPK fertilisers and the behaviour of the raw materials normally used by S.A.P.E.C., a two-phase program was set up:

1st: laboratory tests;

2nd: trials on a pilot plant scale.

1. Laboratory tests:

Attempts were made at compacting in a laboratory compactor the raw materials available at S.A.P.E.C.:

- ammonium sulphate;
- diammonium phosphate;
- potassium chloride;
- super 18%;
- urea.

An attempt was then made to compact mixtures, the moisture content of which does not exceed 1.5%, containing initially hardly any sulphate and diammonium phosphate to which potassium chloride, urea and SSP were added afterwards.

10 kg of each product were compacted in the tests, the following being varied:

- the speed of the rollers;
- the speed of the endless screws;
- the distance between the rollers;
- the compacting pressure.

The main conclusions of this test series are the following:

- The raw materials mentioned can be compacted, although SSP shows special difficulties.

- The mixtures 20-20-0, 13-13-21 and 15-15-15 enable satisfactory results to be obtained.

- The mixtures containing inert materials (kaolin, limestone, diatomite) led to less satisfactory results.

- The ammonium sulphate is responsible for the greater part of the particle size range from 2 to 4 millimetres.

- Within certain limits, recycling assists in the compacting operation.

2. Trials on a pilot plant scale:

The tests carried out in the laboratory were repeated in the pilot plant.

This plant comprised:

- a compactor (smooth rollers having a diameter of 520 mm and a length of 200 mm);
- a flake-breaker;
- a hammer-mill fitted with a 15 mm exit grating;
- a two-stage vibratory screen.

The pilot plant scale trials confirmed in essence the conclusions from the laboratory phase.

PRODUCTION PLANT

1. Description:

The flow-sheet of the plant is attached and comprises:

- 1 raw material feeding device with lump crushers;
- 6 raw material hoppers (one for the recycling operation);
- 2 hoppers for micro-elements;
- 1 metering system, controlled by a micro-computer acting on two weighing points (micro-computer batching controller);
- raw material mixing drum;
- safety screen and electromagnet;
- endless screw-feeder, compactor and flake-breaker;

- hammer-mill;
- two-stage screen;
- mixing drum for the final conditioning of the product;
- de-dusting system.

The materials are transported by a mixed system of hoists, conveyor belts and endless screws.

2. Characteristics of the equipment:

Compactor:

- variable speed corrugated rollers, Ø = 710 mm, width = 320 mm.

Endless screw:

- variable pitch and speed.

Mill:

- exit grating: 18 x 18 mm; variable speed.

Two-stage screen:

- surface area: 2 x 4.34 m^2; upper stage mesh: 4.5 x 4.5 mm, lower stage mesh: 2 x 13 millimetres.

Power supply:

- transport: 128 kW;
- compacting: 307 kW;
- granulation/classification: 98 kW;
- de-dusting: 119 kW.

3. Improvements of the original project:

- improvement in the raw material mixing system;
- modifications in the de-dusting system;
- simplification of some circuits;
- introduction of a conditioning system for the final product (anti-dust and anti-caking).

4. Some operating characteristics:

4.1 Mass balance:

hourly tonnage: 10 t/hour;

recycling of fines: 60 to 65% of the feed;
tonnage at compactor inlet: 30 t/hour;
tonnage at mill inlet: 40 to 60 t/hour;
tonnage at screen inlet: 40 to 60 t/hour.

4.2 Electrical energy unit consumption:
45-50 kWh/tonne.

4.3 Labour:
separately: 2 men per station;
jointly with other sections: 1 supervisor and 1 feed operation

4.4 Characteristics of manufactured products:

We have already manufactured an enormous range of fertilisers, intended either for the export market or the home market:

- ammonium sulphate;
- NP: 14-36-0, 20-20-0, 20-50-0;
- NPK: 5-24-24, 7-21-21, 12-24-12, 13-13-21, 15-15-15, 15-20-15 + 1 B_2O_3, 15-25-15 + 5 S + 1 B_2O_3, 17-17-17, 20-20-20.

Chemical characteristics:

- The nitrogen derives from ammonia or amides.
- The potassium derives from the sulphate or chloride.
- The micro-elements introduced are generally boron-type (Colemanite, fertiliser borate) and magnesia (Kieserite, magnesium oxide).

Physical characteristics:

- Grain hardness: Of the three conventional methods for evaluating the grain hardness (crushing strength, impact strength and abrasion resistance), only the last was used. The irregular nature of the grains makes it impossible to obtain results that agree with those obtained by other methods. The abrasion resistance of the compacts is similar to that of the granules.

- Bulk density: lower for the compacts.
- Caking: A moisture content of 1 to 1.5% and a temperature of about 30°C do not present any more serious mass setting problems than in conventional granulating operations.

The only special problem arises from the formation of loose powder which complicates the handling operations in bulk loading and unloading and in bagging. Following a very long trial series, we are about to start up a treatment unit for the finished product (anti-dust and anti-caking-setting).

ADVANTAGES OF THE COMPACTING METHOD

We at S.A.P.E.C. have three NPK fertiliser production plants in full operation:

- Two plants (10 and 20 t/h) in which a solid raw material mixture is attacked by sulphuric acid, phosphoric acid and ammonia.
- One compacting plant with a throughput of 10 t/hour.

This new plant has provided S.A.P.E.C. not only with an increase in capacity for a much lower than average cost, but also with the following:

- absence of drying and cooling equipment, resulting in savings in energy and cost;
- possibility of introducing organic products;
- absence of economy of scale, making the installation of small factories economically possible;
- possibility of producing small batches;
- correspondence between the composition of each granule and the composition of the fertiliser (thus complex fertilisers);
- reduction of problems involving corrosion and the use of high-grade materials, since all operations take place in the dry state;
- possibility of producing more concentrated fertilisers than in conventional plants;

- possibility of producing fertilisers intended for fertiliser irrigation and compacted fertilisers which can be used later on for the production of fertilisers in liquid suspension;
- possibility of incorporating natural phosphates, useful in acid soils.

AGRONOMIC CONSIDERATIONS

From the point of view of particle size distribution, the compacted fertilisers are similar to the granular fertilisers, having however the advantage of containing a low percentage of products of less than 1 millimetre.

In mechanical spreading operations, whether for placement or with rotary spinners, the behaviour of the granules is similar to that of the compacted products.

In view of the difference in density, the adjustment of the equipment has to be altered in certain cases.

Several experimental field trials have been carried out. For example, in the case of wheat, granular and compacted (14-36-0) products were compared and similar behaviour was confirmed, although there was a certain tendency to obtain better results with the compacted fertiliser. In the trials with wheat, the production of grain and of straw, the specific gravity, the quality of the products and the residual effects of the fertilisers and of the crops in the soil were studied.

ECONOMIC CONSIDERATIONS

1. Leaving aside provision for depreciation, we compared the manufacturing costs of our plants (compacting and conventional granulation) and we have concluded:

-Variable costs:

Leaving the fuel oil out of account, the cost price in the two plants is the same; (the fuel oil costs us $ 208.00 per tonne of fertiliser).

- Fixed costs:

  We arrived at the same figures.

  We may conclude that the manufacturing costs of the two plants differ solely in the value of the fuel oil.

2. With respect to raw materials, the two plants are equivalent.

3. The capital cost for a compacting plant is less than that for a conventional granulation plant.

   The compacting plant described above costs one million dollars.

AMMONIUM SULPHATE

	TESTS RUN				
	Nº 1	Nº 2	Nº 3	Nº 4	Nº 5
HYDRAULIC PRESSURE, BAR	200	200	200	200	200
TONNES/cm	7,2	7.2	7,2	7.2	7.2
ROLLER SPEED	12	16	16	16	16
SCREW SPEED	20	24	22	22	21
FLAKES					
THICKNESS mm	5	5-6	5	5	5
WIDTH mm	180	180	180	180	180
SCREEN OUTLET					
> 4 mm %	20.5	51.3	39.1	53,4	60.0
< 2 mm %	57.1	24.3	37.0	26.5	20.2
2 - 4 mm %	22.3	18.3	23.8	19.8	19.8
EQUIPMENT LOAD					
SCREEN INLET - kg/h	3 390	6 980	5 520	7 679	7 540
COMPACTOR INLET - kg/h	2 700	3 440	3 300	3 800	3 360
% FINES IN THE FEED	71	49	64	51	42
PRODUCTION KG/H	750	1 270	1 350	1 440	1 380
ABRASION	0.65	0.5	0.6	0.55	0.4

13.13.21

FORMULATION (Phos.Am. → 25%
(Sulf.Am. → 39%
(Chlo.Pot.- 35%

	TESTS RUN				
	Nº 1	Nº 2	Nº 3	Nº 4	Nº 5
HYDRAULIC PRESSURE, BAR	120	120	120	120	120
TONNES/cm	4,3	4,3	4,3	4.3	4.3
ROLLER SPEED	16	14	16	16	16
SCREW SPEED	30	25	28	28	28
FLAKES					
THICKNESS mm	4	4	4	4	4
WIDTH mm	180	180	180	180	180
SCREEN OUTLET					
> 4 mm	40.4	40,8	51,7	34.9	41.4
≤ 2 mm	34.0	34,6	27,6	38.2	32.2
2 - 4 mm	25.6	24,6	20,7	26.9	26.4
EQUIPMENT LOAD					
SCREEN INLET - kg/h	5 100	4 360	5 800	4 600	5 340
COMPACTOR INLET - kg/h	3 200	2 670	2 800	3 100	3 180
% FINES IN THE FEED	50	54	57	53	53
PRODUCTION KG/H	1 200	1 020	1 200	1 160	1 380
ABRASION	0.45	0.45	0.4	-	2.2

AMMONIUM SULPHATE

	TESTS RUN		
	Nº 1	Nº 2	Nº 3
HYDRAULIC PRESSURE, BAR	170	170	170
TONNES/cm	7	7	7
ROLLER SPEED rpm	31	31	31
SCREW SPEED rpm	120	100	100
FLAKES			
THICKNESS mm	17	12	12
SCREEN OUTLET			
>4 mm	33.1	29.6	37.2
<2 mm	43.8	46.2	40.8
2 - 4 mm	23.1	24.3	22
EQUIPMENT LOAD			
SCREEN INLET - kg/h	42 000	41 600	46 800
COMPACTOR INLET - kg/h	28 100	29 300	29 400
% FINES IN THE FEED	66	66	65
PRODUCTION KG/H	9 700	10 100	10 300
ABRASION	0.8	0.5	0.5

SETUBAL

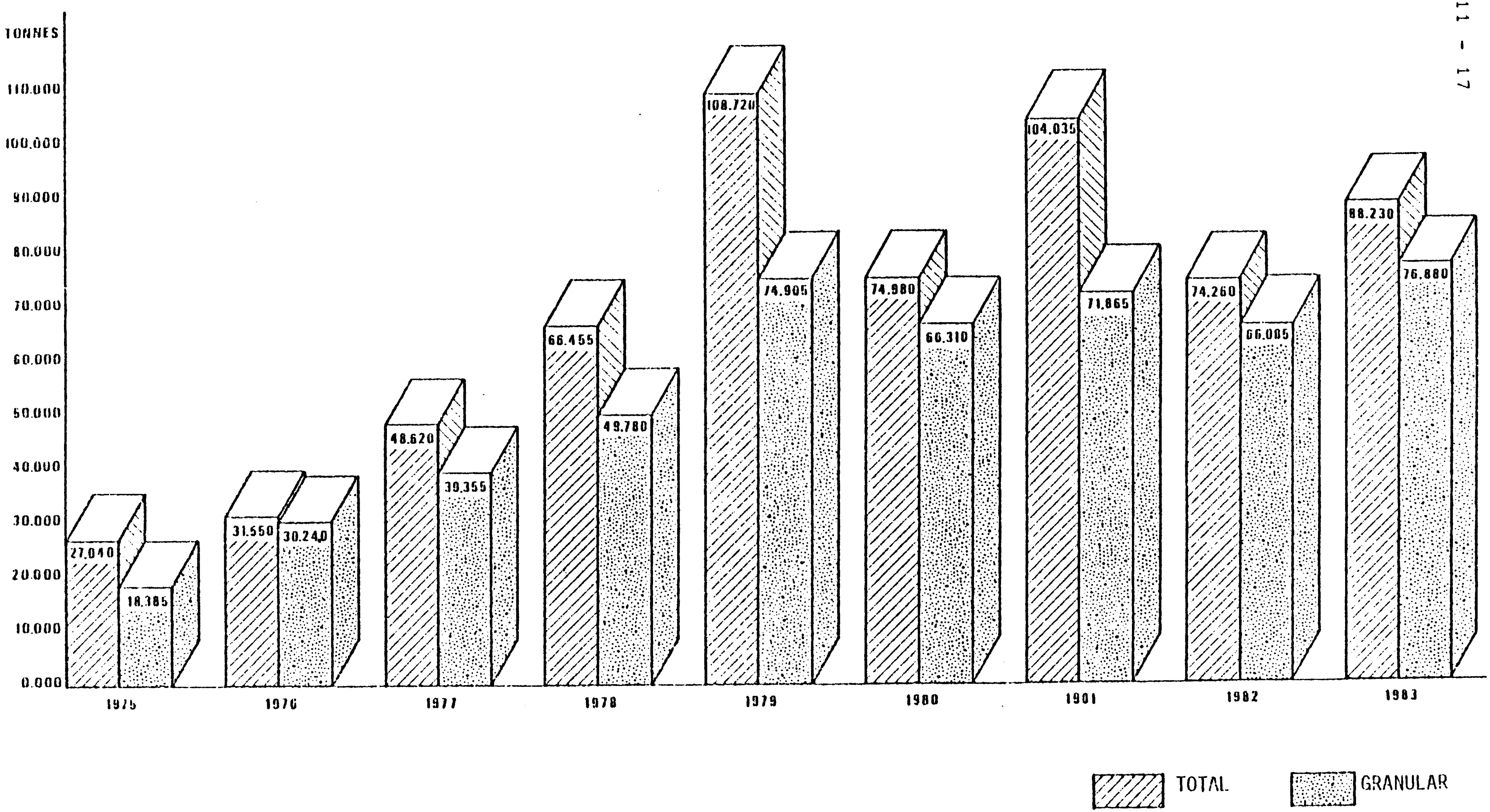
7.21.21

FORMULATION (Phosrock 285
(MOP 350
(Ph.Amm. 365

1000

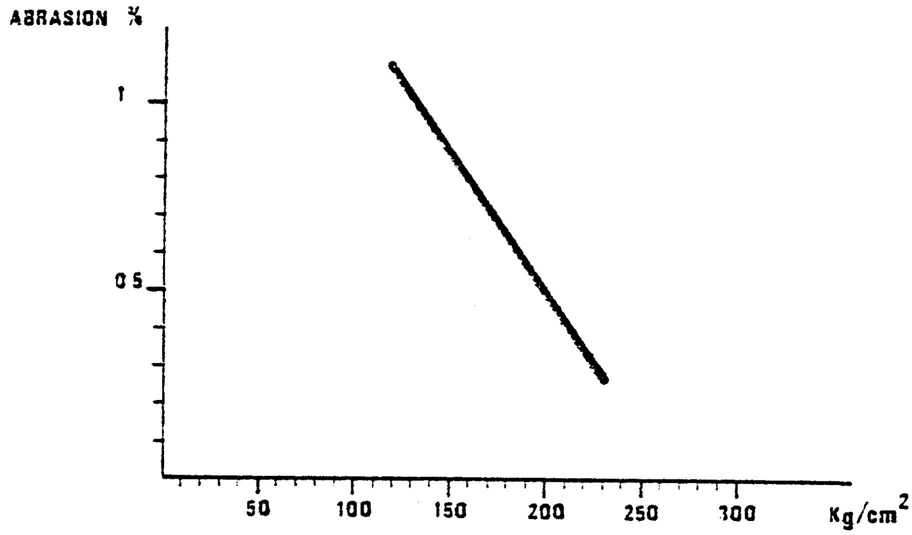
	TESTS RUN		
	Nº 1	Nº 2	Nº 3
HYDRAULIC PRESSURE, BAR	150	150	150
TONNES/cm	6.25	6.25	6.25
ROLLER SPEED rpm	31	31	31
SCREW SPEED rpm	100	100	100
FLAKES			
WIDTH mm	12	12	12
SCREEN OUTLET			
> 4 mm	37.2	29.5	33.1
< 2 mm	40.8	46.2	43.8
2 - 4 mm	22	24.3	23.1
EQUIPMENT LOAD			
SCREEN INLET kg/h	50 000	44 400	45 900
COMPACTOR INLET kg/h	31 400	31 300	30 700
% FINES IN THE FEED	65	65	65
PRODUCTION kg/h	11 000	10 800	10 600
ABRASION	0.5	0.5	0.75

SAPEC EXPORT - TOTAL AND GRANULAR

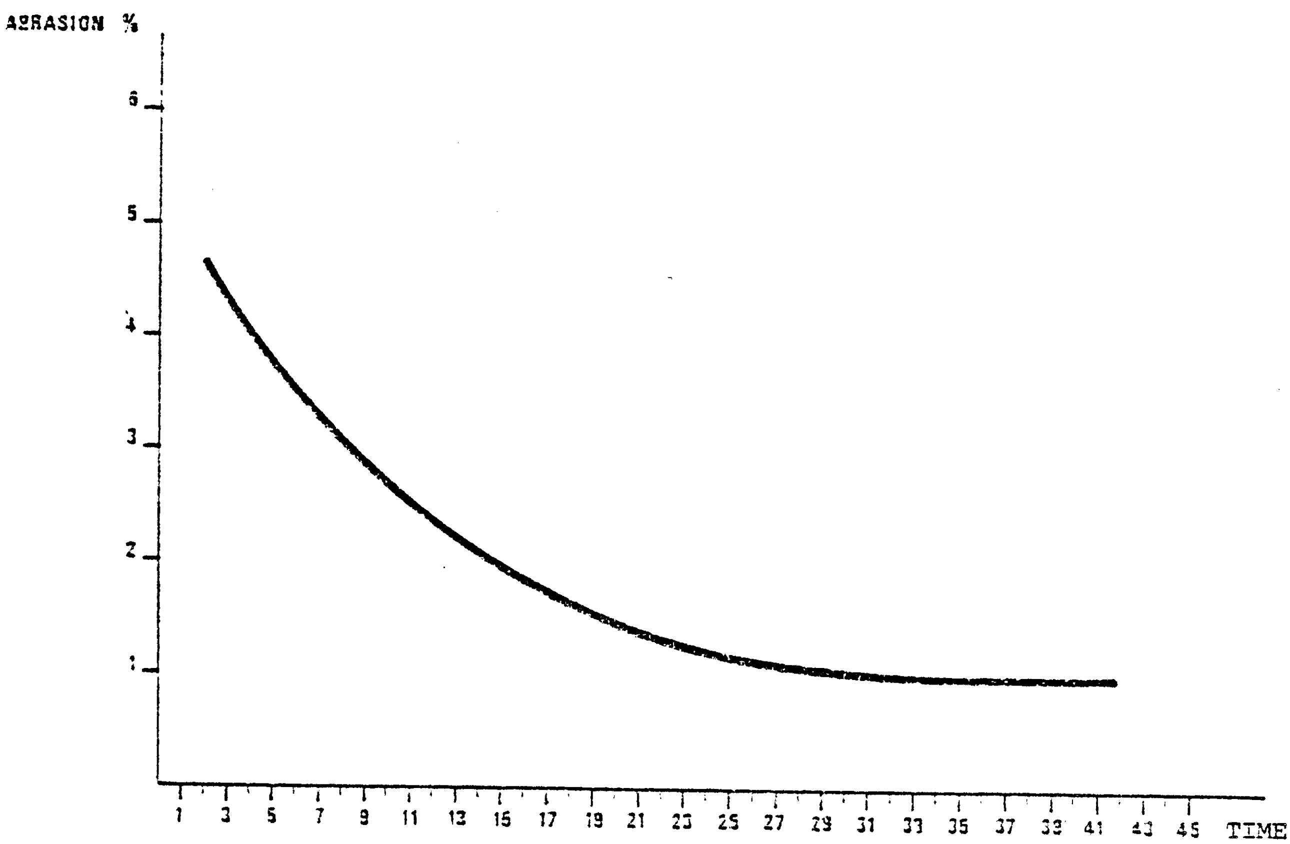


VARIATION OF THE ABRASION OF THE FINISHED PRODUCT

a) IN RELATION TO THE PRESSURE OF THE HYDRAULIC SYSTEM



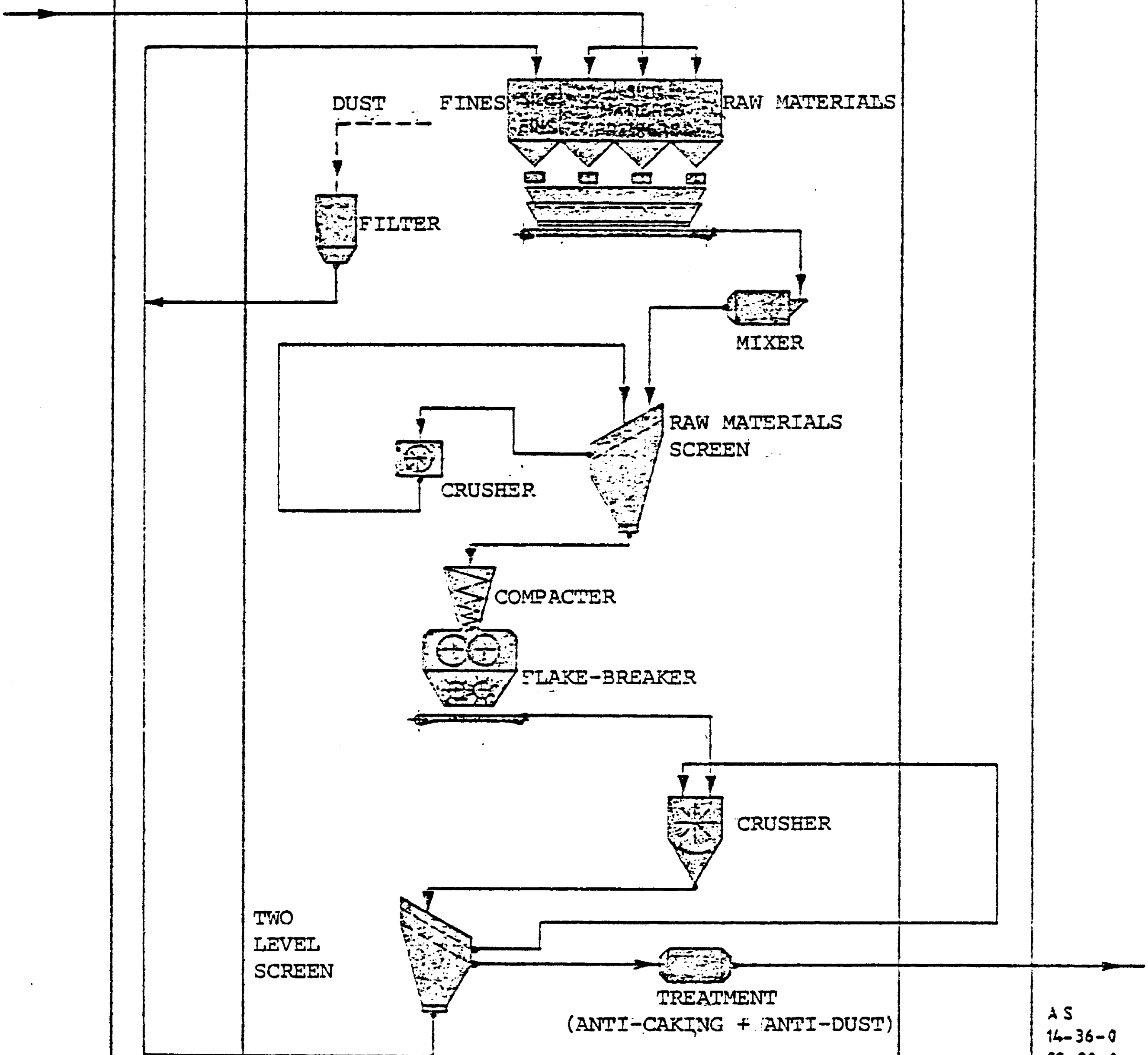
b) IN RELATION TO THE MANUFACTURING TIME



RAW MATERIALS	RECYCLE	COMPACTION - SAPEC	RECYCLE	FINISHED PRODUCT

RAW MATERIALS:

U
AS
DAP
PHOSPHATE
MOP
SOP
SSP
TSP

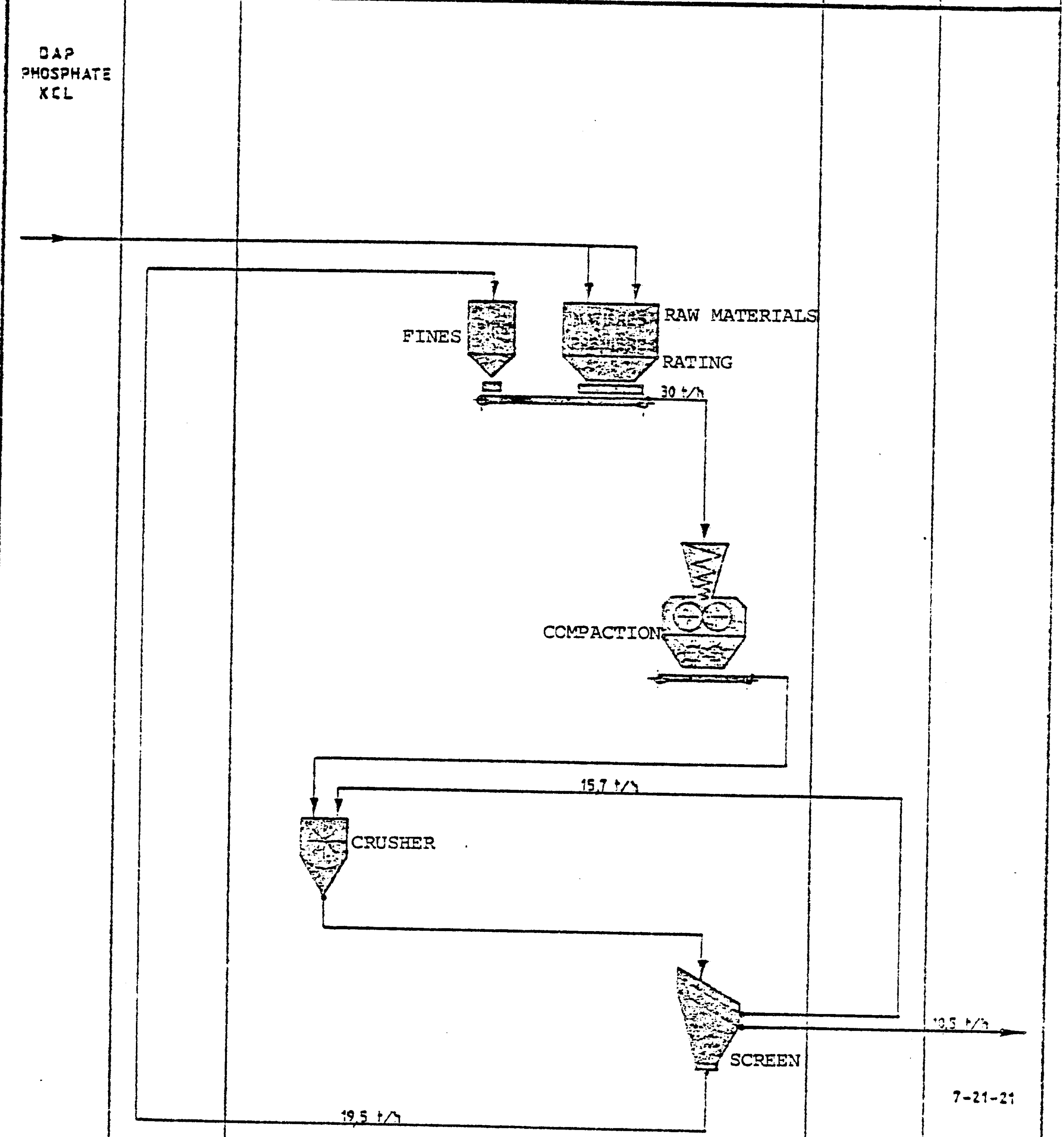


FINISHED PRODUCT:

AS
14-36-0
20-20-0
20-30-0
5-24-24
7-21-21
12-24-8
15-15-15
15-20-15+8
15-25-15+S+8

FLOW-SHEET 11 - 20

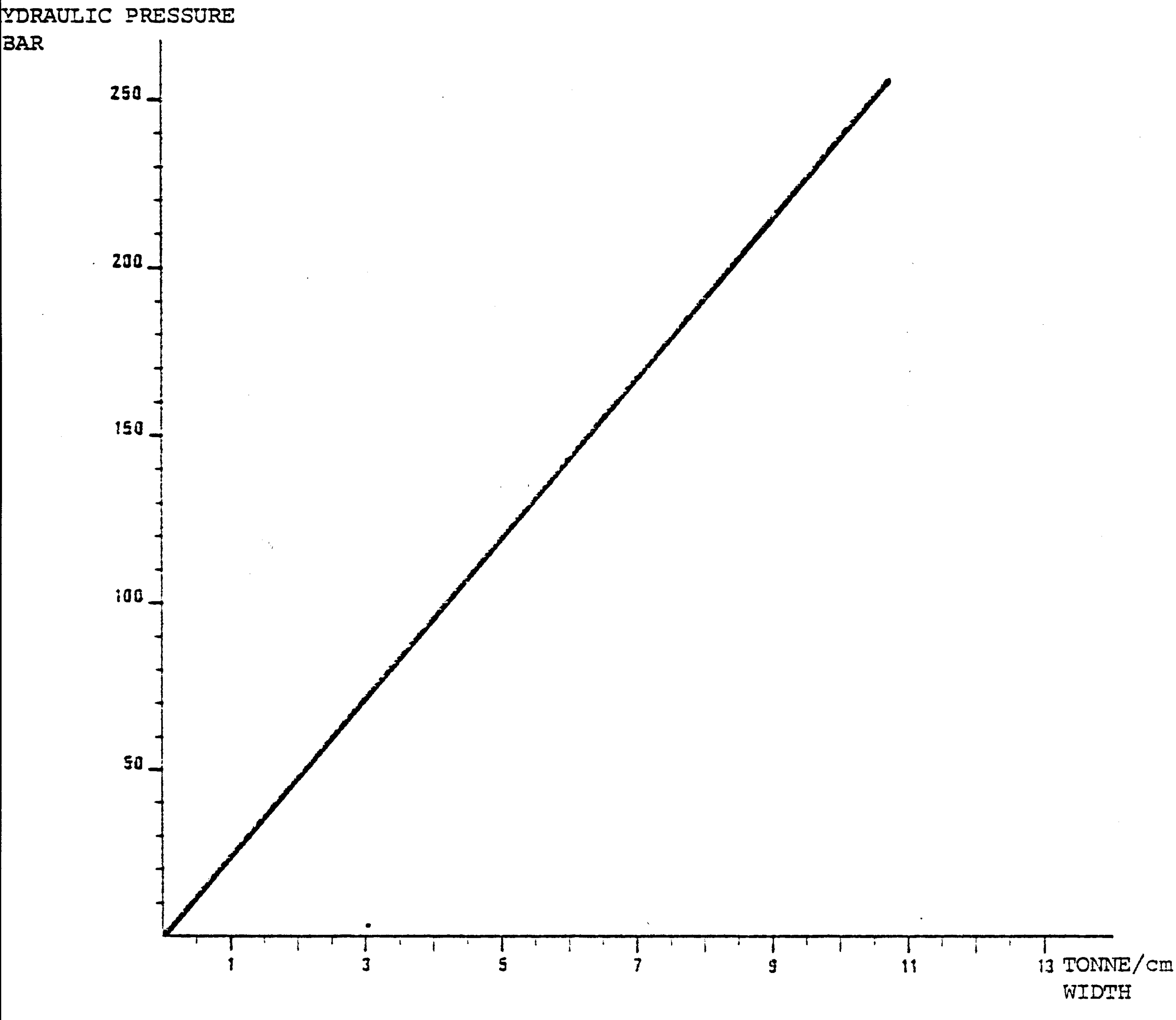
RAW MATERIALS	RECYCLE	COMPACTION - SAPEC MASS BALANCE 7-21-21	RECYCLE	FINISHED PRODUCT



EFFICIENCY

PRODUCT/FLAKES = 35 %
PRODUCT/FLAKES + COARSE = 23 %

COMPACTER


YDRAULIC PRESSURE
BAR
250
200
150
100
50
1
3
5
7
9
11
13 TONNE/cm
WIDTH

TA/84/11 Compacted fertilizers by A. Seixas, J.D. Ribeiro Marçal & J. Correia, SAPEC, Portugal

DISCUSSION: Rapporteur N.D. WARD, Norsk Hydro Fertilizers Ltd, United Kingdom

Q - Mr. M. BARLOY, Office Togolais des Phosphates, Togo

a. Concerning the addition of SSP to the formulation:

- What are the water and free P205 contents of the SSP?
- What is the curing time requested before SSP is used?
- What is the maximum amount which can be added in the formulation?

b. What is the maximum permissible moisture content of the compacted materials and where is the limit: compacter clogging or quality of the finished product?

c. Is natural moisture evaporation significant during manufacture and can it be enhanced?

d. Can you indicate what would be, at present US $ rate, the relative investment cost of a 20t/hr compaction unit as compared to a conventional granulation unit of the same capacity using the same raw materials?

A - a. When it is produced, our SSP contains 10% H2O and 3-4% free acidity, expressed as P205.
An increase in the curing time of SSP is favourable to compaction. Minimum time: 10 days.
To obtain a satisfactory output in t/hr, 10-20% SSP are not exceeded.

b. Since we use a mixture of raw materials, it is important to know the humidity of the mixture. The quality of the finished product limits the humidity.

c. Since the process involves a high recycle rate, the temperature of the product increases and the humidity decreases.

d. The facilities described (10 t/hr) cost $ 1 million in 1980.

Q - Dr. B.K. BHATTACHARYA, FAI, India

How do compacted NPK fertilizers compare with granulated products in terms of uniformity in composition, particle to particle?

A - In view of the successive operations of compaction, grinding and screening, and the high recycle rate, the particles produced in a conventional granulation plant and in a compaction plant are similar in their composition.

Q - Mr. Y. COTONEA, CdF Chimie, France and Mr. P. ORPHANIDES, PFI, Greece

Can you indicate the raw materials used in the production of 20-20-20?

A - To manufacture 20-20-20 we use potassium chloride (0-0-60), ammonium phosphate (20-50-0) and urea (46-0-0).

Q - Mr. J.D. CRERAR, Norsk Hydro Fertilizers Ltd, United Kingdom

a. How much dust becomes detached from finished granules during handling, packaging and transport?

b. 1-1.5% moisture seems high for urea containing fertilizers. Please give experience of storage life and characteristics.

A - a. The finished product contains less than 1% of products below 1 mm. We carried our abrasion tests on granular and compacted products and the results were similar (0.5-1%).

b. The humidity of the finished product varies according to the composition of the mixture. When we add urea to the mixture before compaction, the humidity of the finished product is below 1%.

Q - Mr. M. HANDLEY, IM & C, USA

What is your experience with roll life on NPK's?

A - The rolls we use have a life time of about 8000 hrs, if we carry out intermediate fillings.

Q - Mr. N. KOLMEIJER, Windmill Holland, Netherlands

I presume it is necessary to coat urea-containing granules to prevent caking in storage. Can it be done effectively bearing in mind that the granules are far from spherical?

A - The finished product is coated in a drum with anticaking and antidust agents.

Q - Mr. J. LE PAGE, ICS, Senegal

a. Did you try to compact powder MAP either alone or mixed? of which origin?

b. How does it behave?

c. What is the maximum permissible moisture content?

A - a. We did not compact MAP alone, but mixed.

b. We used Tunisian MAP. It has a good behaviour, although we had dedusting problems.

c. The moisture content is about 2%.

Q - Mr. N. LOUIZOS, SAHPEC, Greece

a. What is max. urea percentage used and corresponding production capacity?

b. What are limitations regarding size distribution of granules i.e. is it better to use the same size, or different size of granules?

c. How often is it necessary to repair or change the compacting cylinders and could this be done in your own installation?

A - a. The amount of urea used depends on the nature of the mixture. So far we did not exceed 30%.

b. In the mixture to be compacted we can use materials of different particle size.

c. The finished product contains 90% of product between 2 and 4 mm. The rolls of the compacter have a life time of 8000 hrs, if there is an intermediate filling.

Q - Mr. A.G. ROBERTS, ICI PLC, United Kingdom

Could the author give more details of the "special-difficulties" experienced with SSP?

A - Since SSP has important plasticity properties, it raises difficulties. We have tried to compact SSP alone and we incorporate it in some fertilizers we produce.

Q - Mr. R. SCHOEMAKER, UKF, Netherlands

Have you got any experiences on the compaction of urea-ammonium sulphate mixtures, such as the 41-0-0-5, as was mentioned by Mr. Bizzotto in his presentation?

Is it necessary to crush urea before the compaction stage?

A - We do not grind urea before compaction.

So far we have not tried to compact mixtures of urea and ammonium sulphate to produce 41-0-0-5.