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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

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07906

DP/ID/SER.B/122
20 February 1978
English

TECHNICAL CONSULTANCY ON FERTILIZER INDUSTRY*

SI/RLA/76/803

Terminal report

Prepared by the United Nations Industrial Development Organization, executing agency for the United Nations Development Programme

Based on the work of R.S. Kachwaha, expert in fertilizers

United Nations Industrial Development Organization

Vienna

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id. 78-921

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Annexes

CONCLUSIONS AND RECOMMENDATIONS

1. Prefeasibility report emphasizes the need for a fertilizer plant in Honduras which, even though having the largest arable area under cultivation has the lowest fertilizer consumption. This is primarily because the entire fertilizer requirement of the country is imported and the price being high, only afluent cultivators in the organized sector can afford the use of fertilizers. The demand survey conducted by the UNIDO consultant along with the ECLA consultant and CABEI expert, have come at the conclusion that there is adequate justification for a NPK complex plant of, at least, 500 tons/day capacity for Honduras alone. If the requirement of entire Atlantic Coast of Central America along with Belize and the Caribbean Islands, which would be within the economic distribution zone, is taken into consideration, it may be possible to justify even a high capacity of 750 tpd of NPK plant. However, for lack reliable data it has been suggested to install a complex plant with a capacity of 500 tons/day and consider installing a fluid fertilizer plant at one of the locations of concentrated consumption. It has also been suggested that if more reliable information is available at the time it is decided to invite tenders, tenders may be invited on two alternative basis of 500 tpd and 750 tpd NPK.

2. The location of the plant is suggested near Puerto Cortes, which, besides being the best developed port in Central America is ideally situated to serve the area of concentrated consumption of Sula Valley.

3. The modern processes for production of nitro-phosphate, namely, the crystallization process and the sulphate recycle process, have been discussed at length and ultimately the sulphate recycle process has been recommended. The total capital outlay of the plant has been estimated as \$25.864 million. Including an escalation factor of one year at the rate of 10%/yr. and including the deferred revenue for training of staff and seeding programme, the total capital requirement has been estimated as \$28.7338 million. The cost of production and the profitability of the plant has been worked out at three levels of capacity utilization, that is, 100%, 90% and 80%. The cost of production including interest on working capital and depreciation works to \$130/MT, \$132/MT and \$134.33/MT for 100%, 90% and 80% capacity utilization respectively.

4. The profitability analysis have been worked on the basis of prevalent cost of similar grade of NPK fertilizer produced in Central America. The profitability had also be worked out at two levels of production, that is, 90% and 100% productions levels.

7. Regarding the process for the manufacture of nitrophosphate, the two processes at present most developed are -the crystallization process and the sulphate recycle process. The crystallization process, even though in commercial operation for a longer period, has higher capital cost and the cost of production as compared to the sulphate recycle process. Sulphate recycle process is also more flexible and, if required, can yield higher percentage of water soluble P_2O_5. Sulphate recycle process has, therefore, been recommended. Crystallization process, however, has an advantage that, in the event adequate quantity of CO_2 is not available, calcium nitrate can be used as a fertilizer by itself. Calcium nitrate, however, is extremely hygroscopic and even though coated with paraffin, it is dobtful if it would be a suitable fertilizer for the climatic condition of Central America.

5. The return on capital employed works out to 14.2% at 90% production level and 17.14% at 100% production level.

6. The debt/equity ratio has been taken at 40% equity and 60% loans from different financial sources with an average rate of interest on the loan capital at 10.5%. After taking into consideration the interest on borrowings the profit has been worked out and the return on equity works out to 19.74% at 90% production level and 27.1% at 100% production level.

7. The Break-Even point at the prevalent selling price works out to about 42% and the pay-back period has been calculated as 6.4 years approximately.

8. Profitability has also been worked out on the basis of international prices of fertilizers of similar grade quoted in journals. Taking the landed price of imported fertilizers at Puerto Cortes, after taking into consideration the freight of handling and other port charges. Profitability on this basis is indicated in Table 6-B, and Break-Even point in Table 7-B.

9. From the above analysis it is concluded that this in an extremely viable project and would result into considerable national benefit, direct and indirect for the country.

10. The capital cost of the 500 tpd NPK plant, including the support facilities, but excluding the bulk ammonia storage facilities, as indicated paragraph 3 above, has been estimated as $17.961 million, the total capital outlay including spares, working capital, financing charges, project management and a contingency of 10%, but excluding escalation, deferred revenue for one year and has been estimated as $25.864 million.

11. On the basis of the specific consumption indicated by the process designers and the current price of the raw material and utilities, the cost of production has been estimated as $130 per MT at 100% capacity utilization. This cost of production is extremely favorable, compared to the current ex-factory price of the equivalent FERTICA product, and may be competitive even with the international product imported to Honduras. The profitably figures, Break-Even

level and the pay-back period are extremely attractive. Even addition of a storage facilities for 10,000 MT of ammonia is not likely to make a significant difference.

12. As indicated under chapter I the maximum area under cultivation is for basic grains, but because of the high price of imported fertilizer they are unable to use fertilizer, I would, therefore, recommend that either this category of cultivators should be subsidised by way of suitable price rebate, easy credit or there should be no objection to having a differential price for this category for first five years and they should be provided adequate agronomic assistance. If properly guided they could prove to be the best consumers. Also they should be better organized by encouraging them to form cooperatives.

13. I was somewhat unfurtunate in not having the advantage of discussions with agronomists to have an idea of agronomic requirement of percent water soluble P_2O_5 and requirement of micronutrient and trace element, even though on many occasions I had expressed this desire. While examining this report this limitation should be kept in mind.

14. The cost of production has been calculated on the basis of raw material cost, nearly all of which have to be imported, based on exploratory inquiry. If competitive quotations are invited and hard bargain resorted, it should be possible to get a better price. Since cost of raw material plays an important part in the cost of production this should further improve the economics.

15. Information received just after the report had been completed indicates that the basic FOB price taken is slightly on the higher side. There should, therefore, be no fear of the capital cost estimates being low and the profitability being too high or wrong.

16. . . I would, however, once again, before concluding this report, emphasize the need of immediate, repeat immediate, action for the establishment of ammonia-urea manufacturing facilities without any further delay.

CHAPTER I

INTRODUCTION

For my assignment, item No.7 of the Job Description reads as follows: "Prepare prefeasibility study for the production of complex fertilizers identified in the SIECA study, to satisfy the 1985 Central American needs".

SIECA in its report has suggested 29 alternatives grouped in seven different patterns. All the locations suggested are on the Pacific Coast except for one at Amatique which is on the Atlantic Coast. It is understood, the mammoth plant suggested at Amatique has been, subsequently, discarded as this was primarily based on the considerations of the likely installation of a refinery at Amatique where the proposed crude oil pipeline from the Pacific Coast to the Atlantic Coast would terminate. Besides, Honduras has been completely ignored as the location for a fertilizer industry.

One of the objectives of UNIDO's participation, as well as, the objective of CABEI in the industrial development of various countries is to ensure that less developed countries are given equitable chance for development. Besides the equitable development of the industries in Central America, I have closely examined the agricultural development, the industrial development and the priorities that should be given for establishment of new industries. At table 1, is an abstract of the information collected from the report UNIDO/IOD 23 of 11th

November 1975, titled Directory of Fertilizer Production Facilities in Latin America. From this table it would be noticed that, whereas Honduras is one of the largest countries in Central America its per capita gross national production, is the lowest of the five Central American countries under consideration ($320). Also, whereas agriculture forms 35% of the portion of G.D.P., which is the highest in Central America, manufacturing activity forms the lowest (15%). Whereas agriculture forms the primary activity, with the entire 823 thousand hectares of the arable land under cultivation, per hectare consumption of fertilizer in Honduras is the lowest among the five Central American countries, which reached a maximum of 38.8 kg/Hect. in 1971 and then declined to 25 Kg. per hectare in 1974, as compared to the highest of 228.7 Kg per hectare for Costa Rica (reference table 5, on page 15 of the SIECA report). The reasons for such a low consumption of complex fertilizer (N.P.K. fertilizers) for Honduras could be traced to the fact that the fertilizer application is restricted to the organized sector for development of cash crop which has a total cultivation of 202.5 thousand hectares and 335 thousand hectares devoted to cereals, which forms 40.7% of the area under permanent cultivation is held by small farmers, who are not able to use the fertilizer. This, I understand, is mainly because the entire fertilizer consumed in Honduras is imported and the price being high and there being no incentive/credit/subsidy or organization to form and organize the cooperatives, this sector of farming remains completed neglected. This is, therefore, a very important consideration given for location of the new fertilizer complex. It has, therefore, been rightly

TABLE I

Country	Land Use 1000 Hectares			N.P.K.	G.N.P.		Approximate Distribution G.D.P.	
	Total Land	Arable Land	Under Permanent Crop	Nutrient Cons. Kg/Hect.	Total Million Dollars	Per capita Dollars	% Agriculture	% Manufacturing
	1	2	3	4	5	6	7	8
Costa Rica	5,070	283.3	207.2	228.7	1,150	630	22	19
El Salvador	2,139	488	163	132.7	1,250	340	25	19
Guatemala	10,889	116.5	319	54.5	2,340	420	28	16
Honduras	11,209	823	823	38.8	860	320	35	15
Nicaragua	13,000	715	158	106.2	1,020	470	26	19

G.D.P. Gross domestic production

G.N.P. Gross national production

Col.4 From Table 5 page 15 of the SIECA report on Possibility of Development of an Integrated Industry of Fertilizers in Central America.

Other Col. From Directory of Fertilizer Production Facilities, Part IV - Latin America.- UNIDO/10D23, 11 th. November 1975 suggested that I should concentrate on the location of the complex plant in Honduras. In this connection, I am reproducing an extract of Mr. Rosenthal's letter dated 4th November to me and an extract of my reply dated 14th of November to Mr. Rosenthal.

Extract of letter dated 4th November:

"Specifically, I would like to place emphasis on point 7 of your terms of reference which essentially should represent the bulk of your efforts for preparing a feasibility study for a complex fertilizer plant to be located in Honduras, in accordance with the expressed wishes and objectives of the Central American Bank for Economic Integration, as a contribution towards a more equitable and balanced development of the fertilizer industry in the region".

Extract of letter dated 14th November:

"SIECA report has identified number of locations for establishment of complex fertilizer plants to meet the requirement of Central America by 1985. If I devote all the remaining time for the feasibility study for Honduras (a worthwhile report would require nearly all the time available), what would be the fate of the other locations recommended. At most, on the basis of information contained in SIECA's report (which is very sketchy), I could only very briefly touch on those locations without making a personal market survey or even personally visiting the locations. This, of course, would not be of any use. Whether UNIDO,Vienna, would accept this position and not look at it adversely?. I presume, you would be able to take care of this".

As a matter of fact, in the limited time available, it was not possible to prepare prefeasibility study for more than one location, leave aside all the alternatives contained in SIECA's report. Accordingly, in deference to CABEI's wishes and Mr. Rosenthal's advice this report deals exclusively with the locations of a NPK fertilizers complex on the Atlantic Coast of Honduras. The Atlantic Coast of Honduras has many advantages as it has one of the best ports in Central America. Bulk of the raw materials required for the fertilizer complex, such as rock phosphate, sulphur and phosphoric acid, (if necessary), potasium, crude oil or petroleum products, required for ammonia plant, as well as ammonia, if necessary, are mostly available on the Atlantic Coast of North America or South America or Africa, and the equipment required for the fertilizer factory would, most probably, have to be imported from Europe or the U.S.A. The locations of a plant on the Atlantic Coast would avoid transport of these materials through the Panama Canal and the cost of these materials on the Atlantic Coast is likely to be cheaper. A location on the Atlantic Coast could serve not only the needs of Honduras, but the entire Atlantic Coast of all the Central American countries, as well as the Caribbean. All the fertilizer plants currently installed in Central America are located on the Pacific Coast, and the location of, at least, one plant on the Atlantic Coast has a merit. The NPK complex plant could be the nucleous for the development and growth of auxiliary/ancillary industries based on by-product, coproducts and other feeder industries to meet the requirements of the fertilizer complex.

CHAPTER II

FERTILIZER DEMAND - PLANT CAPACITY

The demand survey for Honduras was conducted by me, along with Mr. Ponciano, ECLA Consultant, and Mr. Alberty of CABEI by visiting the various organizations concerned with the use of fertilizers. This included visit to United Fruit Co., Honduras Banana Corporation (COHBANA), Azucarera Hondureña, Cotton Growers Cooperative, Honduras Coffee Institute, National Planning Board, Agrarian Institute and Ministry of Natural Resources at Tegucigalpa.

While for discussions with the various organizations concerned I accompanied Mr. Ponciano (ECLA Consultant), the Coffee Institute and the Cotton Grower's Cooperative was visited by Mr. Ponciano alone. Also, while discussions with the agronomist of Azucarera Hondureña and Mr. Stover of the United Fruit Co. were, generally, conducted in English, the discussion with other organizations were conducted in Spanish only, with occasional interpretation in English for my benefit. I had, therefore, more or less exclusively, to depend on the report prepared by Mr. Ponciano, ECLA Consultant, for the present demand for fertilizers in Honduras. Mr. Ponciano was good enough to prepare for me an English version of his report. Even though I have taken advantage of this report, I have considered it necessary to make certain deviations, as I considered necessary.

The SIECA report, right in the beginning, has pointed out about lack of true statistical data and that whatever data is available cannot be relied upon.

The survey team also had, more or less, similar experience. On November 11th, when the team met the staff of the Agricultural Planning Department, they were informed that the Department had no quantitative data available and that the data available was only qualitative. On November 22, while discussing with the Deputy Director of the Agricultural Operation Development, the Ministry of Natural Resources, the team was informed that he could only give current programme for basic grains, fruits and cotton only, and that too in terms of acreage planned and not in terms of fertilizer uses. We were also informed that there was no follow-up and it was not certain if the plans were actually implemented. He also emphasized that the fertilizer prices being high (US$ 11/100 lbs) it was not possible to persuade the poorer farmers to use fertilizer, cost-benefit ratio not being favorable.

From Table 71 Page 167 of the SIECA report, projection of NPK fertilizer for Honduras for 1985 is indicated as 53,000 MT whereas, from Table 72 Page 171, projection for 1985 for various fertilizer has been indicated as follows:

Simple N_2 Fertilizers	46,000 MT
S.S.P.	2,000 MT
DAP	3,000 MT
N.P.	30,000 MT
KCl	9,000 MT
NPK	30,000 MT

It is, therefore, not clear how the figure of 53,000 MT has been arrived at.

Nitrogen, P_2O_5 and K_2O are the three primary nutrients required for all the crops. Out of these, nitrogen even though available in the air in ample quantities, has to be converted into a form suitable for use by the plants. P_2O_5 is basically derived from the rock phosphate, where it is present in an insoluble form. The various processes developed involve converting P_2O_5 to a soluble form, either by reacting it with sulphuric acid or nitric acid. In the first stage it is converted to phosphoric acid or mono-calcium phosphates. The different processes developed involve removal of calcium radical or converting it into a water soluble form, so that it is not available for reacting with phosphoric acid radical, and when reacted with ammonia primarily ammonium phosphates or mono-calcium phosphates are formed. Potasium compound is a simple physical addition and no processing is involved. Therefore, quantities of NPK required is primarily determined by the P_2O_5 requirement. The nitrogen associate with it depends upon the process involved and the requirement of the crop to which it is applied. Nitrogen is, in any case, obtained directly or indirectly through ammonia in whatever process is chosen. Therefore, NPK products/processes are, basically, NP processes with such addition as may be necessary of soluble P_2O_5 through SSP, TSP, MAP or DAP to make specific formulations as required. All the groups of non nitrogenous fertilizers such as SSP/TSP should, except straight KCl when it is used only with pure nitrogenous fertilizer, be grouped under NPK complexes. From this point of view, the entire group of non nitrogenous fertilizer in Table 72 of the SIECA report should be classified as NPK and this would give a projected requirement for Honduras for 1985 to a total of 74,000 MT against 53,000 MT indicated has not attained an on-stream efficiency of more than 250 days in a year, and the best capacity utilization has been 96.4% in the year 1976 -after 13 years. Limiting the number of formulation may help increase on-stream efficiency. The World Bank also works, more or less, on similar time schedule and does not expect a capacity utilization of more than 90%, particularly in the developing countries.

It is estimated that 70% of the fertilizer used in Honduras is imported through the Port of Cortes. About 60% of the nitrogen imported as urea is consumed by banana plantations. The main consumer for NPK being cotton, coffee and sugar cane only. Sugar plantations have expanded substancially during the last few years. Agronomic work is proving very useful for sugar and coffee. It is estimated that the four major crops -banana, cotton, coffee and sugar cane- account for 80% or more of the present fertilizer consumption. The import of fertilizer in Honduras from 1975 to 1977 (estimated) nearly doubled from 30,500 MT in 1975; 45,158 MT in 1976 and 60,000 MT (estimate) for 1977. For 1976 urea accounted for 39.4% and NPK, 41.2% of the fertilizer imported. The use of complex fertilizers, particularly for coffee and sugar, is increasing and is very encouraging. The import of complex fertilizers in 1975 was 6,168 MT and in 1976, 19,597 MT (41% of the total imports). The formulations imported in 1975 and in 1976 indicate a substantial increase in phosphate use. The import for 1977 were 25,000 MT, mostly NPK complex.

Whereas, from 1971 to 1975 consumption of urea maintained a leading position, for 1976, the consumption of NPK was higher. The rise in NPK consumption in 1976 appears more than a temporary trend.

The Demand for the Major Crops Grown in Honduras

(a) Bananas:

Bananas form a substantial acreage under cultivation (43,200 acres planted in 1977, out of which 12,000 acres are in the Aguan Valley, and 31,200 acres in the Sula Valley). According to Corporación Hondureña del Banano (COHBANA) it is planned to increase banana planting by 2,500 acres between 1977 and 1979 and another 4,500 acres between 1980 and 1983. This would bring total banana plantation to about 50,000 acres by 1983 or latest by 1985. COHBANA, which was formed only recently, is depending mostly on the other well established plantations like Standard Fruit Company for import of fertilizer and has no experience and have yet not developed its own agronomic organization. It has, therefore, to depend on the experience of the other banana growing organizations. According to the discussions with United Fruit Company officials at Sula Valley, for banana they are using mainly urea and potassium chloride at the rate of 275 lbs. of urea per acre per year and 1,150 lbs of potasium chloride per acre per year. The Standard Fruit Company in the Aguan Valley is using as high as 500 lbs. of urea per acre per year and 1,000 lbs. of KCl per acre per year. At the rate of 500 lbs/acre for 50,000 acres anticipated for 1983, it would work out to 11,364 MT of urea.

COHBANA indicated that, in collaboration with COMUNBANA, an international banana exporters organization formed by the banana exporters covering in Table 71. The ratio of N_2 to P_2O_5 to K_2O would vary depending on the soil and the crop to which the fertilizer is required to be applied. Generally NPK is applied as basal dressing supplement by nitrogen application as top dressing. The ratio of $N:P_2O_5:K_2O$ that may work out from Table 72 would not be significant or meaningful. This, as indicated above, could be varied depending on the crop and soil. The process selected, therefore, has to be flexible to produce any of the grades required. However, for the installation of the plant, one specific capacity has to be decided and this has to be based on the formulation which is in maximum demand. From this consideration, the obvious formulation has to be 15:15:15 (refer Table 18, Page 51 of the SIECA report).

The plant proposed to be installed now would go into full production only in 1988, as per the following schedule:

(a)	Project approval, necessary administrative, managerial and financial arrangement and negotiation for loans, if required, 1 year	end 1978
(b)	Inviting tender and awarding contract minimum 6 months	July 1979
(c)	Design, engineering, supply of equipment installation and commissioning -4 to 5 years (average 4 1/2 years)	Jan. 1984
(d)	Production first year -1984	50%
	Production second year -1985	70%
	Production third year -1986	80%
	Production fourth year -1987	90%
	Production fifth year -1988	95% and above

From FERTICA's experience, even their best operated plant at Puntarenas the entire Latin America -Central as well as South America- they are planning export to non-traditional market and are planning considerable expansion of their activities.

Our discussions with COHBANA as well as the representative of United Fruit Company revealed that for banana there is no application of NPK, as their experience has indicated that there is no response for banana to the application of phosphate. This could, perhaps, be because of the high phosphatic contents of the soil in the areas where bananas are grown. A private business organization would, naturally, look for immediate result, even though this may, in the long run, deplete the soil and, in due course, have adverse repercussions. This is a matter which needs to be examined and evaluated by the agronomists looking after the overall long range national interest rather than immediate benefit. Unfortunately, it was not possible to discuss this problem with their agronomist, as he was out of station.

(b) Coffee:

Coffee is a very important consumer of NPK fertilizer. The area under cultivation in 1977 being 105,000 ha. Fertilizer consumption, this year (1977), was about 25,000 MT., out of which 5,455 MT was urea and 19,545 MT of NPK complex. The projections for 1979/1980 are 11,000 MT of urea and 40,000 MT of NPK, indicating a rate of growth of about 40 to 45% per year over a period of two years. According to the Coffee Institute Officials, the use of NPK complex for coffee is increasing.

(c) Sugar Cane:

According to the estimates of Azucarera Hondureña S.A., which is the leading cultivator in the country, the area planted in 1977 is about 46,000 manzanas (32,200 ha.). This firm estimates an increase of about 4,000 manzanas by 1978-1979, bringing the total area planted to about 50 000 manzanas (35,000 ha.) Their agronomist indicated that they have been entrusted with the planning of the cultivation of sugar cane for the entire country, and that their proposal for the use of fertilizers was about 162 pounds of nitrogen per manzana and the same quantity of P_2O_5. They are planning for use of NPK in the ratio of 2:2:1.5. On this basis the use of nitrogen, P_2O_5 and K_2O for sugar cultivation would work out to 162 pounds of nitrogen, 162 pounds of P_2O_5 and 122 pounds of K_2O per manzana, which would, for 50,000 Mn, give a figure of about 10,000 MT of NPK (in the ratio of 2:2:1.5), by the year 1978-79. Projected at the rate of growth of 10% per year would give, for the year 1988-89, demand of about 26,000 MT of NPK.

(d) Cotton:

Cultivation of cotton, which is primarily an export item, has been widely fluctuating. Fertilizer consumption for 1977 was estimated by the Cotton Cooperative at 4,000 MT of urea and 2,800 MT of NPK. Projected forward at the growth rate of 8% per year for the year of 1988-89, this would give urea demand of 9,330 MT, and NPK demand of 6,530 MT. At the rate of growth of 10% per year it would work out to 11,400 MT urea and 7,990 MT of NPK.

Moreover, cotton is primarily grown on the south coast and may fall beyond the economic zone of a factory located at Puerto Cortes.

(e) Palm Oil (African variety):

About 10,000 acres (4,000 ha.) of palm oil is planted in the Sula and the Aguan Valley. Fertilizer consumption is estimated as 60-100 kg/ha. nitrogen 20-40 kg/ha. of P_2O_5 and 80-140 kg/ha. of K_2O. Consumption of fertilizers for palm oil cultivation, according to the National Agrarian Institute, is very nominal. In fact, no statistics appear to be available. The same is true for the citrus fruits according to Institute's citric fruit program.

(f) Basic grain (corn, beans, rice and sorghum):

Even though largest acerage is under cultivation, the use of fertilizers for this crop is very nominal. We were informed that the price of the imported fertilizers being high, it does not give adequate cost-benefit ratio to the poor farmers engaged on cultivation of basic grains. Agronomic guidelines have not been worked out sufficiently. Since acerage under cultivation under this category is the largest and the farmers handling this cultivation unorganized and poorer adequate incentive and organized assistance in the form of cheap credit/subsidy may be necessary to uplift this category of cultivators and increase food grain cultivation if agronomic studies give positive results. It is estimated that fertilizer application to this crops does not exceed 10% of the total fertilizer import.

(g) Other Crops:

No information is available on use of fertilizer for crops like tobacco, vegetables and other fruit crops.

NPK fertilizers demand was about 20,000 for 1975, which is estimated to rise to 30,000 MT by 1977 for use mainly by coffee and cotton. If to this, use of NPK for sugar cultivation and other crops like tobacco and fruits etc. is added, the expected consumption in 1977 should be even higher. The increase from 20,000 to 30,000 (50% in two years) is primarily due to increase in consumption for coffee. Projection at the rate of growth of 10% per year would give an estimated demand for 1988 to about 85,600 MT of NPK. If to this, projections for sugar and cotton and other crops like basic grains, fruits, tobacco, palm oil, vegetables etc. are added, demand for the year 1988 may approach a total of about 120,000 MT of NPK for Honduras alone.

The fertilizer factory located near Puerto Cortes, need not be limited to serve Honduras requirements only. The entire Atlantic Coast of all the Central American countries, including Belize, as well as the Caribbean Islands, could be very economically served by this factory.

Moreover, it would be useful to bear in mind that, at the point of time when the present FERTICA plants where planned and constructed, fertilizer consumption in Central America was very insignificant. With the availability of fertilizer, demand developed. To make sure that by the time the factory proposed to be installed has a reasonable capacity utilization, it would be necessary that, as soon as a firm decision is taken on the installation of the factory, an appropriate seeding programme is started, so that by the time the factory reaches full production, adequate demand is developed in the command area.

Since the currently available statistics in Honduras are, as stated in the SIECA report, and as found out by us, not adequate and can not be fully relied upon, it would be prudent to take the demand projected in the SIECA report of about 74,000 MT of complex fertilizers by 1985, which should, at the rate of growth of 10% per year reach a demand of about 98,500 MT for Honduras alone.

Plant Capacity:

On the basis of the above projections for 1988 and a capacity utilization of 90-95% it would be possible to justify a capacity of 500 tpd of NPK for Honduras alone. Honduras growing rate for NPK has been 8.4% per year as compared to other Central American countries where the growth rate have been between 10 to 13%. The reasons for low consumption of fertilizer in the past has been already explained by me earlier -high prices of the imported fertilizer. The SIECA report is in favor of a growth rate of 10% per year. Even though the other experts have opined in favor of a growth rate of 8 to 9%, for Honduras in particular, with a very low rate of consumption at present, a growth rate of 10% for the next decade or two with the availability of cheap locally manufactured NPK, would be realistic. As a matter of fact, if this factory is to serve the north east portion of Guatemala, Belize, the entire Atlantic Coast of Central America, as well as, the Caribbean even a higher capacity of 750 tpd may be justified. However, at present, no data about these markets that could be served are available. Therefore, for the time being, it would be prudent to decide in favor of a 500 tpd plant, even though a higher capacity would be more economical due to scale of operation. However, while inviting tenders, quotation can be invited on the basis of two alternative capacities -500 tpd and 750 tpd and, depending on the conditions prevailing at that time, when more reliable information for the entire area to be served by this plant -North east Guatemala, Belize, Atlantic Coast of all the Central American countries, as well as the Caribbean -may be available, decision can be taken whether to install a 500 tpd plant or 750 tpd plant. A decision on the installation of an ammonia-urea plant would have a very important bearing on this. Even though the present decision may be in favor of a non integrated plant, it would be wise at the time of acquisition of land, planning the factory lay out, to leave enough space so that, if considered necessary, ammonia urea facilities can be established at a later date.

In USA and many of the European countries, lately, there is a trend towards increased use of fluid fertilizers, and substantial quantities of fluid fertilizers is being use. It might be worthwhile installing, to start with, a small pilot plant for production and use of fluid fertilizers. If the demand of complex fertilizer is greater than the installed capacity, and if the manufacture and use of fluid fertilizer is encouraging, further installations of fluid fertilizers could be examined. I propose to briefly touch upon this group of fertilizers in subsequent chapters.

CHAPTER III

FACILITIES REQUIRED AND LOCATION

Complex fertilizers contain three basic primary plant nutrients -nitrogen, phosphate and potash. Nitrogen is derived, directly or indirectly from ammonia. Phosphate, even though available and derived from rock phosphate (which is a mineral product) has to be processed and converted into a form which can be taken up by the plants. Potash, which is also a mineral product, is generally available as potasium chloride or potasium sulphate. Since both these potassium compounds are readily soluble in water, these are easily absorbed by the plants and no processing is required, and whatever process may be used for processing of nitrogen and the rock phosphate, potasium compounds are merely added at the finishing stage of the process in the required proportion. The plants also required, occasionally, micronutrients and trace elements depending upon the soil composition and the crops involved. The micronutrients have to be added at the appropriate stage in the process in the quantities as may be required. For nitrogen the main source is ammonia for its direct requirement for the process, as well as, for production of nitric acid, depending on the process involved. If ammonia production facilities are not established adjoining the nitro-phosphate plant as an integral part, it has to be obtained from outside sources. Besides, availability of ammonia for direct use and for the production of nitric acid, ammonia production process generates, as a by-product, large quantities of pure CO_2 which is very essential for some of the processes for production of nitro-phosphate. These processes described in detail in subsequent chapters are of recent development and produce nitro-phosphate which is comparatively cheaper. If CO_2 is not available as a by-product from the adjoining ammonia plant, other source of supply of CO_2 have to be lookea for.

Other major requirements, particularly for increasing the P_2O_5 content of the product, which may be required for certain formulations, are M.A.P.,DAP, TSP and SSP.

Other requirement, which is needed for one of the processes lately developed and considered very economical, is gypsum in small quantities to make up the loses in the process. This requirement is relatively small and the purity of the mineral required need not be very high. In case gypsum is not available, equivalent quantities of sulphuric acid or ammonium sulphate can be substituted.

Other important requirements for the processes are:

a) Fuel oil, which can be used as a feed stock for the production of ammonia in case ammonia production facilities have to be integrated and more economical feed stocks are not available. In any case, fuel oil is required for generation of steam required for most of the processes involved, as well as, a fuel for the furnaces required for heating/drying.

b) Water is required for cooling purposes either directly as available, if quality is suitable, or after necessary treatment. Water is also required for some of the processes involved and has to be of specific quality. The third and the most important requirement of water is as boiler feed water for generation of steam. For this purpose water, from whatever source it may be available, has to be treated and purified to make it suitable for generation of steam.

c) Since most of the moving machinery would be driven by electricity as a motive power, electrical power, in quantities depending upon the processes involved, is required. The stability of electric power is very important for smooth operation. Quantum of power required is generally considerable and it forms a significant part of the cost involved.

d) Besides the above process requirements, in case nitric acid has to be produced, platinum-rhodium is required as a catalyst. Even though the quantity required is very small, this being an extremely expensive material forms an important cost element.

Over and above the process raw materials and utilities indicated above, the plant would need a certain amount of developed land with suitable load bearing characteristics for construction of equipment foundations, nearby source of cement and aggregate for construction of equipment foundations and other building structures. If the land available is not well developed or does not have adequate load bearing quality it would involve additional cost. Similarly, if cement and aggregate has to be transported from long distances, cost would increase. Necessary approach roads and easy access to water-ways, in case product/raw materials have to be transported through inland water-ways/sea, would be required. I understand, Honduras and the neighbouring Central American countries have very limited/no mineral deposits for use as a raw material for the fertilizer industry. Evidently, most of the above mentioned raw materials have to be imported from other countries. Therefore, nearness to a well developed port is a very important factor to be taken into consideration. This would also facilitate export of fertilizer to the neighbouring Central American countries, along the Atlantic Coast, as well as, to the nearby Caribbean Islands. Since most of the plants and machinery required for the factory would need to be imported from the developed countries like the USA, European Countries, or Japan, nearness to a well developed port for unloading and handling of the imported machinery would be of great help.

Location

It was planned to visit few port locations along the Atlantic Coast of Honduras such as, Tela, Ceiba and Castilla. During the period visit to the likely sites was planned, roads to these places were damaged by floods and these places were not approachable. Also, discussions with the port authorities at Cortes convinced the team that Cortes was the best port for the purpose. The only other port being developed at present was Puerto Castilla,but this port was being developed, primarily for wood chips, paper pulp and paper. Besides, Puerto Cortes was ideally situated to serve the major demand market of coffee, sugar cane and banana plantations in Sula Valley. This port was least congested and most developed to serve the needs of a fertilizer factory. The location of the fertilizer factory between the port, the cement factory and near about the oil refinery would, therefore, be ideal. The exact location could only be decided after detailed site survey and soil investigations. This location would also be ideally suitable to serve northeast portion of Guatemala, Belize, the entire Atlantic Coast of other Central American countries, as well as, the Caribbean.

CHAPTER IV

PRODUCTS AND PROCESSES

The SIECA report has concluded that nitric acid acidulation process for production of phosphatic fertilizers is cheaper as compared to sulphuric acid acidulation process. Dr. Hignett, consultant International Fertilizer Development has also, while presenting a paper on technical and economic comparison of nitric and sulphuric acid process routes for phosphatic fertilizers (presented at ANDA/ISMA Seminar, Sao Paulo, Brazil, April 75), concluded that investment requirements, production costs and, therefore, the gate sale prices were lower for the nitrophosphate processes. The Fertilizer Corporation of India has also conducted extensive investigation of this problem and their conclusions are also similar.

The production of nitrophosphates, i.e. fertilizer products obtained from the acidulation of phosphate rock with nitric acid, has been a real possibility for almost 40 years. The sulphur shortage in the world and its widely fluctuating prices, has sparked renewed interest in the treatment of phosphate rock with nitric acid for fertilizer production.

Extensive work on nitric acid acidulation was carried out in late 50's by Messrs. Potasse and Engrais Chimique (P.E.C.) and Messrs. Uhde. There have been further development work in mid 60's by TVA, FCI, as well as Messrs. Stamicarbon, particularly on sulphate recycle process.

The product of the acidulation of phosphate rock with nitric acid is a solution principally containing phosphoric acid, together with a co-produced calcium salt. Most of the technological developments in the nitrophosphate field have been focussed on suitable treatment of this co-produced calcium compound. Since calcium nitrate is water-soluble, unlike calcium sulphate, its removal requires more complicated techniques. The removal or avoidance of this calcium nitrate plays a major part in the technology of nitrophosphate processes.

Two processes have been developed and are in operation on commercial scale. Both of these make use of the attack of phosphate rock by nitric acid, namely:

1. <u>Sulphate Recycle Process</u>

In this process the calcium is removed as gypsum with the aid of ammonium sulphate. This gypsum is converted into ammonium sulphate, which is used again for removing the calcium, thus completing the circular course of sulphur.

2. <u>Crystallization Process</u>

Here, the calcium is removed by freezing out calcium nitrate tetrahydrate. The calcium nitrate can be processed in two ways:

a) Production of calcium nitrate as a straight N-fertilizer.

b) Conversion of calcium nitrate into ammonium nitrate.

The Sulphate Recycle Process (See figure 1)

The process may be divided into a number of process stages.

1. Dissolution Stage

The dissolution of the rock phosphate makes the P_2O_5 component available in a water or citrate-soluble state.

Automatic weighing equipment discharges the phosphate rock into the first dissolution tank, where it is mixed with the proper amount of nitric acid. The main reactions which occur in this dissolution stage are the following:

$Ca_3(PO_4)2 + 6\ HNO_3$ ——————— $3\ Ca(NO_3)_2 + 2H_3PO_4$

$CaCO_3 + 2\ HNO_3$ ——————— $Ca(NO_3)_2 + H_2O + CO_2$

$Ca_3\ (PO_4)_2 + 4\ H_3PO_4$ ——————— $3\ Ca\ (H_2PO_4)_2$

The evolving CO_2 causes foaming in the dissolution vessels, for which reason anti-foaming agent is introduced.

The excess nitric acid is determined by the desired N/P_2O_5 -ratio in the end-product. Frequently the aim is to obtain a low N/P_2O_5 -ratio, yielding a product in the 24-16 range. This, however, depends on the type of rock used and the desired %-range of water-soluble P_2O_5.

The exothermic dissolution reactions raise the temperature of the mixture to about 65°C. In the second-stage dissolution tank the reaction is completed and the dissolved liquid flows over to the storage tank via a filterpot or an inert centrifuge, depending on the type of phosphate rock used.

2. Precipitation and Filtration Section

A solution of ammonium sulphate and the dissolved solution are fed in a certain ratio to the first precipitation reactor.

For instance if a maximum amount of water-soluble P_2O_5 is desired in the end-product, all of the dissolved solution in a given ratio with the ammonium sulphate is sent to the precipitation section. However, if a mixed fertilizer with a lower water-soluble P_2O_5 content is wanted, only part of the dissolved solution is fed to the precipitation stage, whilst the other part by-passes the precipitation and filtration sections.

A predetermined part of calcium is now precipitated as gypsum, which, in fact, controls the water-soluble P_2O_5 content of the end-product.

The acid solution reacts as a solution of calcium nitrate in a mixture of phosphoric acid and nitric acid.

Calcium nitrate is converted into $CaSO_4 . 2aq$, which precipitates.

The reaction is carried out in such a way that an easily filterable precipitate is formed.

The slurry, which now contains gypsum, phosphoric acid and nitric acid, flows over continuously into a second-stage reactor, and from there into the filteration section.

The filteration, which is completed on a belt filter, can be divided into the following stages:

1. Filtration
2. 2 or 3 washings of the gypsum cake
3. Drying of the cake by suction
4. Removal of the gypsum cake

The filtrate is collected, via separators, in a tank and, subsequently, flows over to the storage tank for dissolved liquid.

As has been observed, if low water-soluble P_2O_5 content is desired in the end-product, part of the acid solution by-passes the precipitation-filtration section and is fed to the storage tank direct, so that the filtrate may contain some calcium nitrate.

In the neutralization section the $Ca(NO_3)_2$ forms di-calcium phosphate, which is not water-soluble.

It is also possible to decrease the total nutrient content of the end-product if the filter is by-passed, so that some calcium sulphate is added to the filtrate.

3. <u>Neutralization and Evaporation</u>

The neutralization is a delicate part of the process.

If, for instance, an NP fertilizer is to be produced with a water-solubility of less than 100%, too high a pH value will lower the water-solubility and the citrate-solubility of the P_2O_5 in the end-product.

On the other hand, too low a pH value poses problem because of the possibility of decomposition, owing to the acidity of the product. Generally, the high pH causes the ammonia losses to increase and the low pH may result in a higher viscosity of the solution, giving rise to problems in the concentration and the prilling stages.

The main neutralization reactions are as follows:

$HNO_3 + NH_3$ ———— NH_4NO_3

$Ca(NO_3)_2 + H_3PO_4 + 2\ NH_3$ ———— $CaHPO_4 + 2\ NH_4NO_3$

$H_3PO_4 + NH_3$ ———— $NH_4H_2PO_4$

$CaSiF_6 + 2\ Ca(NO_3)_2 + 4NH_3 + 2\ H_2O$ ———— $4\ NH_4NO_3 + 3\ CaF_2 + SiO_2$

$Ca(NO_3)_2 + 2\ H_3PO_4 + 2\ NH_3$ ———— $Ca(H_2PO_4)_2 + 2\ NH_3NO_3$

Being exothermic, the neutralization reactions will cause the temperature to rise. Depending onthe N/P_2O_5 ratio and the water-solubility of the P_2O_5, boiling in the neutralizer is possible.

The amount of ammonia is regulated by automatic pH control.

After the neutralization, the solution has to be concentrated.

The evaporation presents special problems, because, at a concentration of about 80% the boiling point of the mixture is lower than the crystallization point of ammonium phosphate.

To solve the problem of a crystallizing compound in a boiling solution, a circulation-type evaporator is chosen.

For reasons of economics, the evaporations is mostly realized in two stages.

In the first stage the solution is concentrated from about 50% to 74% (boiling temperature about 120°C).

In the second stage evaporator the temperature of the circulating melt is about 170°C, which is higher than the crystallization point.

If the NPK fertilizer has to be prilled, the second-stage evaporation is carried out in vacuum, and the concentration is about 99%.

But if the NPK fertilizer has to be granulated, the second-stage evaporation is atmospheric and the concentration of the melt is about 95%.

Prilling Section

The concentrated NP melt is pumped to the top of the prilling tower, where potassium salt may be added to a mixing cyclone. The potassium salt is then added in proportion with the amount of NP slurry. The temperature in the mixing vessel is kept at 160°C. The mixture is fed to a prilling bucket, which distributes the product in the form of droplets over the cross-sectional area of the prilling tower, in which a rising air flow is maintained, induced by 4 fans installed at the top of the tower.

Both the mixing cyclone and the prilling buckets are of special design. During their fall, the droplets solidify into prills. The prills are removed from the bottom of the tower by means of a scraper and, prior to being transported to bulk-storage, they are cooled, screened and coated with kieselguhr or an equivalent coating agent, preferably in combination with an oil-amine mixture. Oversize product is crushed and recycled; undersize product is recycled to the NP melt tank.

Short description of the granulation process

The wet section of the plant is the same as that for prilling units, i.e. up to the second-stage evaporator, which now operates at atmospheric pressure and produces an NP melt of about 95%.

This melt is pumped to a head tank which feeds the granulation screw.

Together with this melt, also the undersize, the crushed recycle of oversize product, and the potassium salt are fed to the granulation screw. The granules are then transported to a drum, where the product is dried until the required final water content is obtained. Subsequently, the product is led to the cooling drum.

A bucket elevator transports the granules to a screen for separation of the oversize and undersize product, the oversize being crushed and recycled, together with the undersize, to the granulating screw.

Product of the correct size is passed through a second cooling drum to be given its final temperature, whereupon it is sent to a storage shed via a coating drum.

The gypsum filtered off in the precipitation-filtration stage is converted into ammonium sulphate with the aid of ammonia and carbon dioxide, so that fertilizers can be produced without formation of by-products and without consumption of sulphur, some gypsum being used for make-up. In fact this gypsum conversion plant completes the circular course of the sulphur.

The gypsum conversion has been known and used in Europe for many years.

Carbon dioxide and ammonia are fed to an absorbent where the following reaction takes place:

$$2NH_3 + CO_2 + H_2O \longrightarrow (NH_4)_2CO_3$$

The formed $(NH_4)_2CO_3$ solution is fed to the conversion reactors.

$$CaSO_4 + (NH_4)_2CO_3 \longrightarrow CaCO_3 + (NH_4)_2SO_4$$

The ammonium sulphate solution is pumped back to the precipitation stage of the NPK plant, after filtration of the $CaCO_3$ precipitate.

Crystallization process (see figure 2)

Ground phosphate rock and nitric acid are fed in the proper ratio to the dissolution tank, where the attack of the phosphate rock takes place.

From a second-stage dissolution tank, in which the dissolution is completed, the liquid flows over into a storage tank.

In fact, the dissolution section is exactly the same as the discussed in connection with the sulphate recycle process. However, in the crystallization process an excess quantity of HNO_3 has to be used to avoid formation of mono-calcium phosphate $Ca(H_2PO_4)_2$ already during the dissolution. This mono-calcium phosphate crystallizes together with, or even before, the $Ca(NO_3)_2$. From the dissolution tank the liquid is pumped through a cooler to reduce the temperature to about 35°C.

The calcium nitrate-tetrahydrate is crystallized by cooling in a few crystallizers arranged in series. The final calcium nitrate concentration is decisive of the end temperature of the cooling range, which, in its turn, is a function of the phosphate rock and the concentration and excess amount of the nitric acid used for dissolution.

The extent of the $Ca(NO_3)_2$ crystallization depends also on the molar N/P_2O_5 ratio in the dissolution liquor after centrifuging.

The CaO/P_2O_5 ratio is a highly important figure, because it controls the water-soluble P_2O_5 found in the end-product.

The laboratory, therefore, periodically determines the CaO/P_2O_5 ratio of the dissolution liquor after the centrifuge.

As cooling agent a calcium nitrate solution has been chosen to prevent the dissolution liquor from being polluted in the event of leakages.

The crystallizers are heated periodically with a calcium nitrate solution of about 70°C in order to melt any deposits on the cooling elements.

The calcium nitrate crystals are removed in a continuous centrifuge. The dissolution liquor is then suitable for further processing. To avoid the loss of P_2O_5 with the calcium nitrate, the calcium-nitrate-tetrahydrate is washed with fresh, cooled nitric acid.

The liquor, whose calcium nitrate content has been reduced by the cooling, is further neutralized, evaporated, prilled or granulated, cooled and coated with coating agent. These steps have already been discussed.

However, the evaporation in the crystallization route is often carried out in one stage, unlike the sulphate recycle route.

The above mentioned calcium nitrate-tetrahydrate may be processed and sold as calcium nitrate fertilizer or be converted into ammonium nitrate.

A. Production of Calcium Nitrate Fertilizer (see figure 3)

The washed calcium nitrate-tetrahydrate crystals are melted in a tank by means of indirect steam. The melt is fed to a neutralizer, to which also some nitric acid may be added in order to obtain the composition 5.2 $Ca(NO_3)_2$ · 1 NH_4NO_3.

The contents are then neutralized with ammonia. In an evaporator the melt is subsequently concentrated until a nutrient content of 15.5% N in the final product is reached. This concentrated melt is prilled in oil, i.e., the molten calcium nitrate drops fall into an oil-paraffin mixture of a lower temperature. The drops solidify into prills with non-hygroscopic properties. The prills are separated from the oil in a discontinuous centrifuge and stored after screening.

B. Conversion of Calcium Nitrate (see figure 4)

After the melting and neutralization, calcium nitrate from the crystallization section is passed on to an agitated reaction vessel to which a solution containing carbon dioxide and ammonia is added. In this vessel the calcium nitrate reacts with ammonium carbonate to form an ammonium nitrate solution and solid calcium carbonate.

The slurry is filtered by a rotary drum filter and the crystals are washed with water. The crystals are then discharged from the filter and the ammonium nitrate can, wholly or partly, be returned to the NPK plant, depending on the type of complex fertilizer being produced.

It is also very well possible, however, to process this ammonium nitrate solution into pure ammonium nitrate, a straight N-fertilizer with a high nutrient content.

Product compositions

a) Sulphate recycle process:

Owing to the extra supply of NH_3 -N, along with the ammonium sulphate, to the precipitation section, the N/P_2O_5 ratio in the end-product will be higher than 1. In comparison with the crystallization process, no nitrogen is removed from the acid solution (in the form of calcium nitrate), but extra nitrogen is added to the process by lowering the CaO/P_2O_5 ratio.

The composition of the end-product is determined primarily by the composition of the phosphate rock and the dissolution conditions, and secondly by the relative water-soluble P_2O_5 ratio content of the end-product.

Starting from a Kola phosphate with a CaO/P_2O_5 ratio of 3.3, the end product will have a minimum N/P_2O_5 ratio of 1.53, if P_2O_5 of maximum water-solubility is desired (94%).

If a low-grade Florida rock with a $\frac{CaO}{P_2O_5}$ ratio of 3.8 is used, the N/P_2O_5 ratio will be 1.79, also if a maximum water-solubility is required. A good average NP formula is 24-16.

b) Crystallization process:

Contrary to the sulphate recycle process, here part of the calcium is primarily removed as calcium nitrate, resulting in lower N/P_2O_5 ratios. 70%

of the calcium nitrate can be crystallized easily with use of the above mentioned equipment of the crystallization process, which means that a product with about 60% water-soluble P_2O_5 is obtained.

To remove 95% of the calcium nitrate, a temperature of about -10°C must be reached, so that the end-product contains 80-85% of water-soluble P_2O_5. If cooling is applied until a CaO/P_2O_5 ratio of, for instance, 1.25 is obtained the result will be an N/P_2O_5 ratio of about 0.75 and a water-solubility of 50%.

Flexibility of the nitrophosphate processes.

Flexibility of the sulphate recycle process:

The nutrient content and ratio can be varied in several ways. The nutrient content may be controlled simply by by-passing the filter and varying the gypsum content of the end-product.

The following possibilities are available to vary the N/P_2O_5 content:

1. By using less ammonium sulphate solution for precipitation less nitrogen will be introduced per ton of available P_2O_5. This results in lower N/P_2O_5 ratios. At the same time, less calcium is precipitated as calcium sulphate, and, during neutralization of the solution with ammonia, water-insoluble calcium phosphates will be formed.

The N/P_2O_5 weight-ratio may vary between 1.38 and 1.53 for Kola phosphate, if the percentage of water-soluble P_2O_5 varies between 50 and 94% (see figure 4).

2. Recirculation of the solution, after precipitation, into the dissolution stage. The N/P_2O_5 ratio will decrease by about 0.2 (recycle ratio 4:1)

through the presence of the phosphoric acid in this solution, which acts as an acidulant. This is a new mode to lower the N/P_2O_5 ratio, by which the same percentage of water-soluble P_2O_5 is obtained without increasing the cost price of the product.

3. Addition of phosphoric acid.

This H_3PO_4 may be introduced in the acidulation stage, which means that a complete dissolution of the rock can be obtained with a deficiency of nitric acid (lowering the amount of N introduced by it) owing to the fact that this extra supply of H_3PO_4 to some extent contributes to the acidulation of rock phosphate.

The H_3PO_4 may also be added first before the neutralizer, which means, however, that in order to obtain the same NP ratio, the amount of extra P_2O_5 has to be higher than in the first situation.

Basically, there are no limitations on the N/P_2O_5 ratio. If the melt has to be prilled, the N/P_2O_5 ratio should not be below 0.8.

4. Supply of MAP/DAP.

The addition of MAP is preferred to DAP in case one of the ammonium phosphates is used as an external P_2O_5 source because, anyhow, the DAP is converted into MAP in the neutralizer.

This is also the reason why it is not possible to introduce the DAP in a later stage, e.g., after the evaporation (because of the pH value of the melt). MAP can be supplied to the melt vessel direct without this giving rise to any problems.

5. Addition of TSP.

Addition of TSP to the melt vessel results in a melt with such a high viscosity that it is no longer possible to prill the product.

However, there is a possibility to supply the TSP before the neutralization stage. But TSP consists mainly of $Ca(H_2PO_4)_2$, which is a salt with water-soluble P_2O_5. In the neutralization this $Ca(H_2PO_4)_2$ will react according to the equation:

$$Ca(H_2PO_4)_2 + NH_3 \longrightarrow CaHPO_4 + (NH_4)H_2PO_4$$

This results in a lower figure for the water-solubility. Superphosphate can be added in a granulation plant without serious problems.

6. Removal of some calcium nitrate by cooling.

It is possible to freeze and crystallize out part of the calcium nitrate. Since only part of the calcium is removed as calcium-nitrate, acceptable crystallization temperature can be selected.

The remaining calcium is again removed as calcium sulphate. This reduces the N/P_2O_5 ratio, whilst a maximum amount of water-soluble P_2O_5 may be obtained. Disadvantages are the higher investment and operating cost and the formation of calcium nitrate as by-product, which, of course, could be converted with ammonium carbonate into the by-product NH_4NO_3.

In general, it may be concluded that it is not possible to reach the N/P_2O_5 ratio of 1 with ammonium sulphate as precipitation agent in the sulphate recycle process without adding P_2O_5 from an external source.

However, N/P ratios, starting at 0.5 and increasing to any value, may be achieved without addition of external P_2O_5 if the calcium-nitrate is removed by precipitation with H_2SO_4 instead of ammonium sulphate. To meet the need for a minimum amount of nitric acid, after filtration some acid is returned to the dissolution tank and is used as dissolution acid.

In this process the water-solubility of P_2O_5 can easily be varied between 30% and approximately 95% maximum, depending on the kind of rock phosphate used.

Flexibility of the crystallization process:

The water-solubility of the fertilizers produced by the crystallization process may be varied between 30% and 80-85% maximum.

To vary the N/P_2O_5 content, the following possibilities are available.

1. Recirculation of different amount of converted calcium nitrate solution before the neutralization stage.

The calcium nitrate separated in the crystallization stage can be converted into ammonium nitrate and calcium carbonate. After separation of these two components, the ammonium nitrate solution can be used either to produce calcium ammonium-nitrate or be recycled to the NP process.

By fluctuating the percentage of the ammonium nitrate solution, recycled, the N/P_2O_5 ratio can easily be varied from 0.6 up to about 1.7-1.8.

2. In case all ammonium nitrate solution is recycled to the NP process the N/P_2O_5 ratio can again be varied as mentioned under the points 3,4 and 5 of

the description regarding the flexibility of the sulphate recycle process.

However, if phosphoric acid is added as an external P_2O_5 source, there would be no point in introducing this H_3PO_4 in the acidulation stage because of the fact that excess HNO_3 is necessary in the acidulation to avoid formation of mono-calcium-phosphate.

This means that H_3PO_4 cannot be used to contribute to the acidulation of rock phosphate.

In the event the plant is not integrated with ammonia manufacturing facilities and CO_2 is not available in necessary quantity phosphoric acid, sulphuric acid or ammonium sulphate can be used. Alternatively crystallization process can be chosen and calcium nitrate (15.5%N_2) produced as a by-product.

Besides, being a very low nutrient product, this product is, extremely hygroscopic and even though the prills are coated with oil-paraffin mixture, it is doubtful if the product would be suitable for the highly humid conditions of Central America.

Figure 1

Flowsheet NP or NPK production with removal of calcium by precipitation

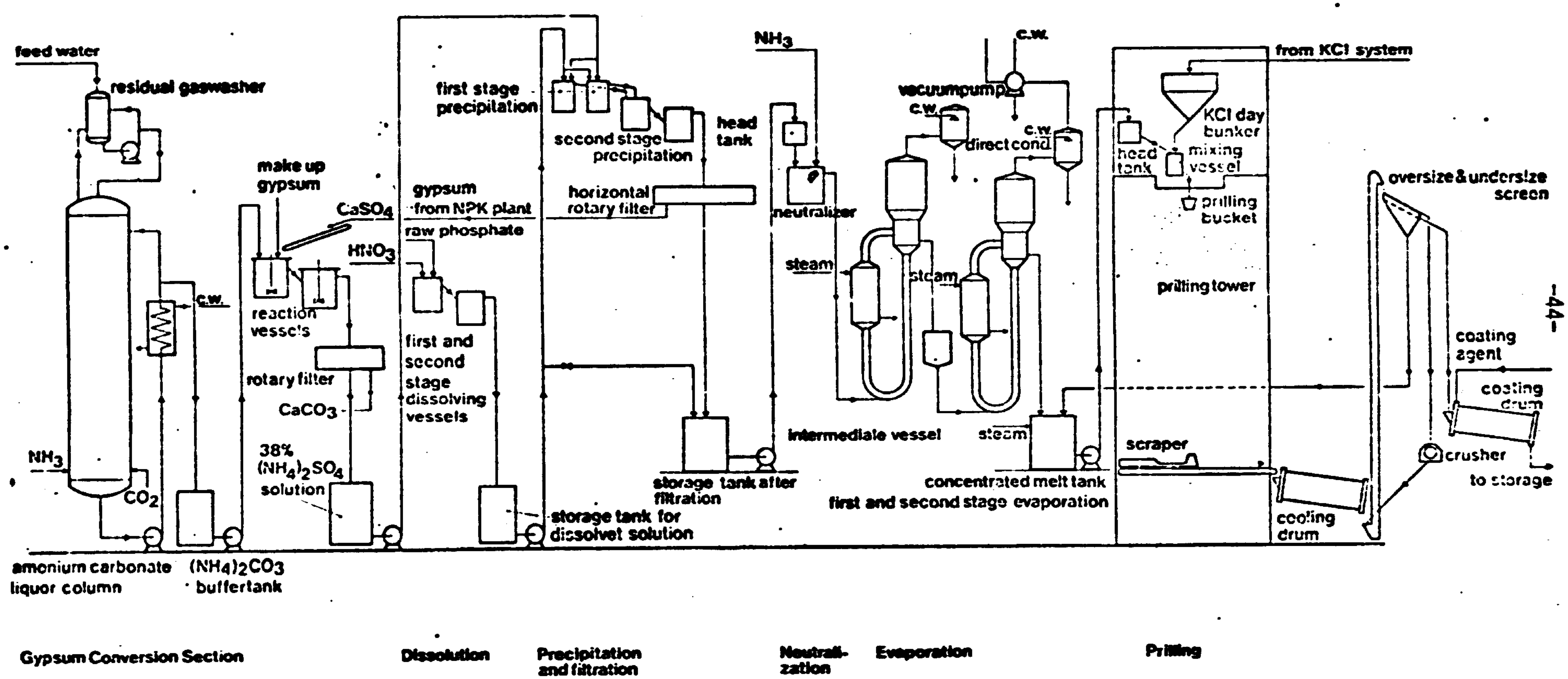


Figure 2

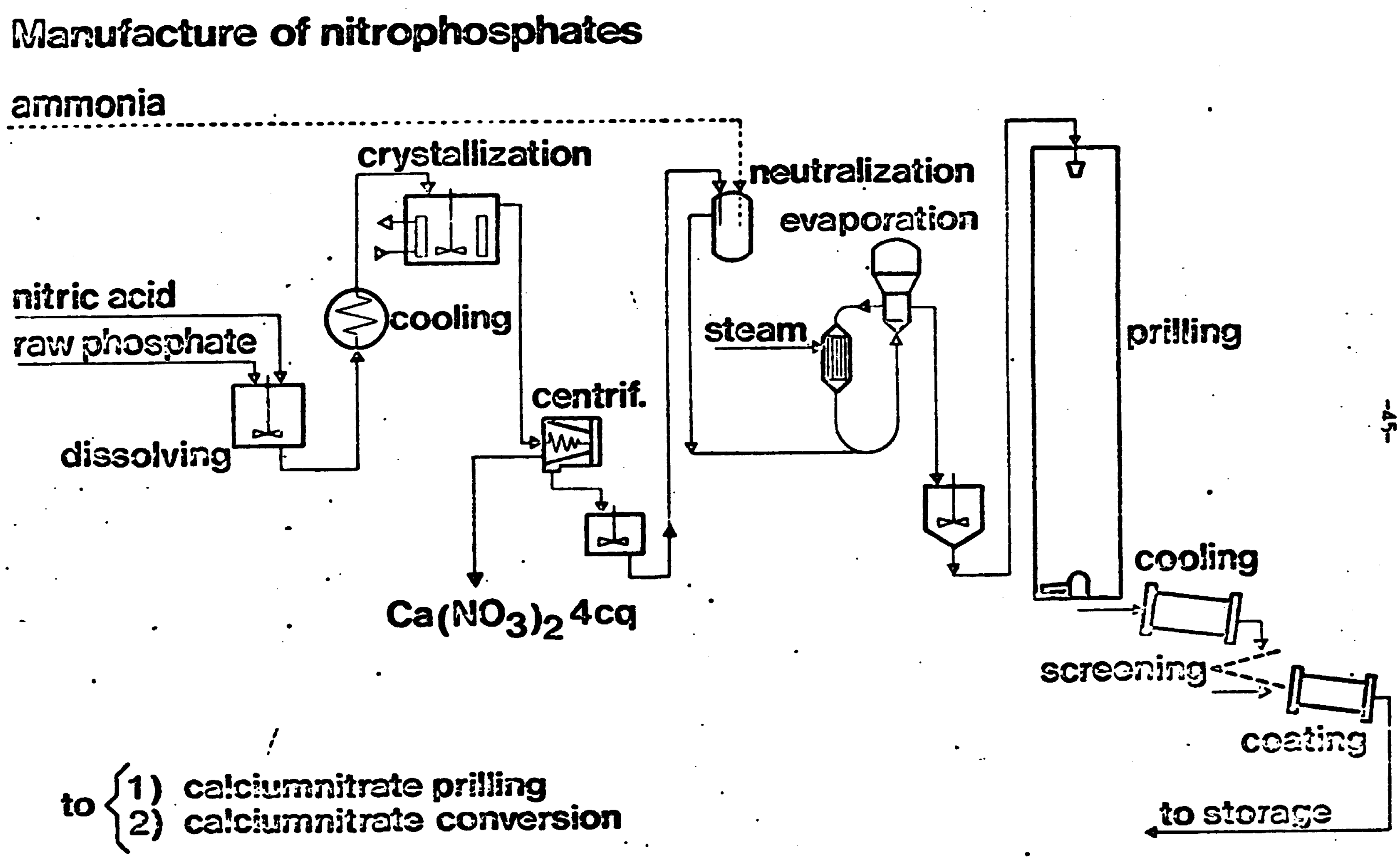

Manufacture of nitrophosphates
ammonia
nitric acid
raw phosphate
dissolving
cooling
crystallization
centrif.
Ca(NO3)2 4cq
neutralization
evaporation
steam
prilling
cooling
screening
coating
to storage
to 1) calciumnitrate prilling
2) calciumnitrate conversion

Figure 3

Flowsheet calciumnitrate prilling

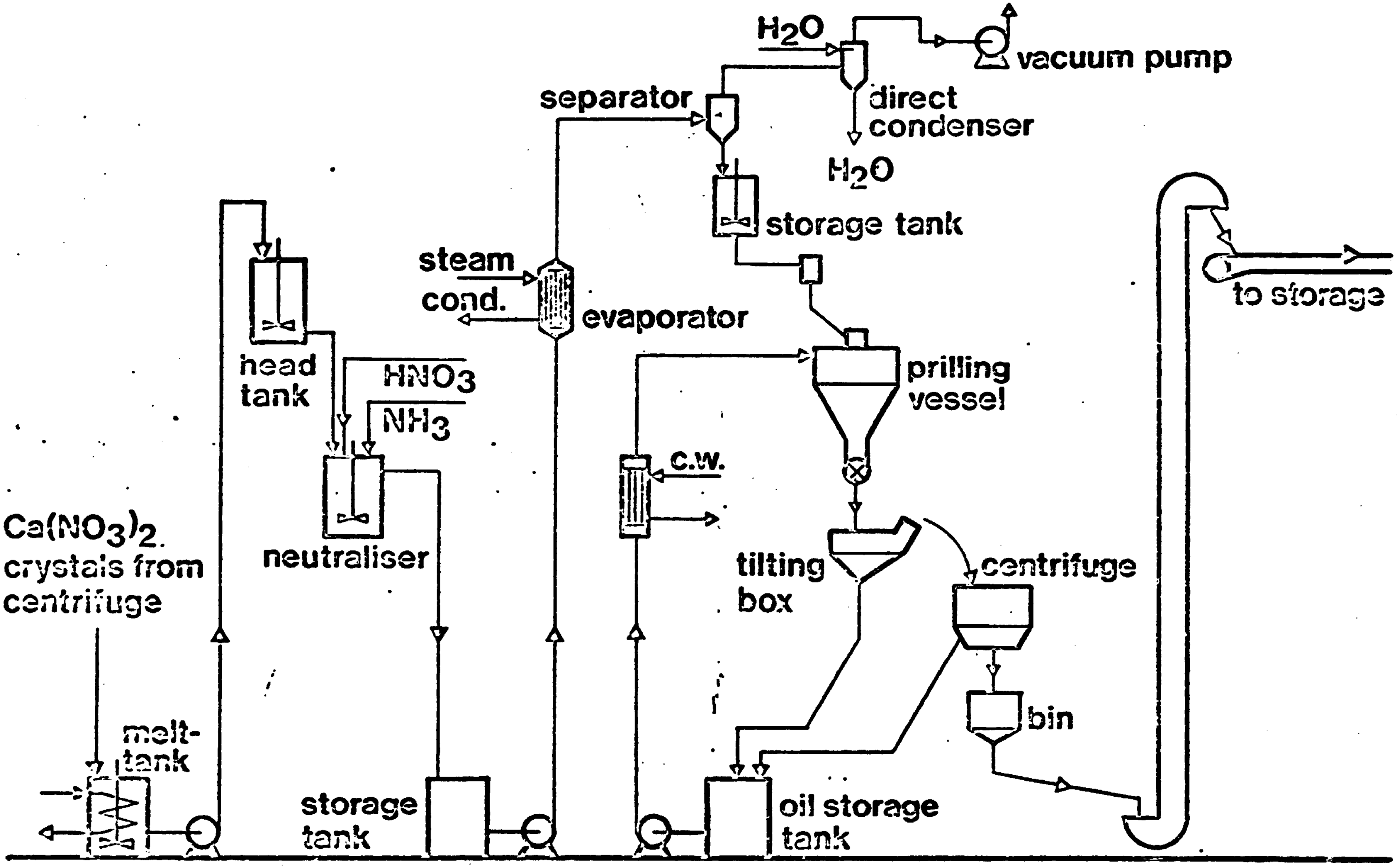
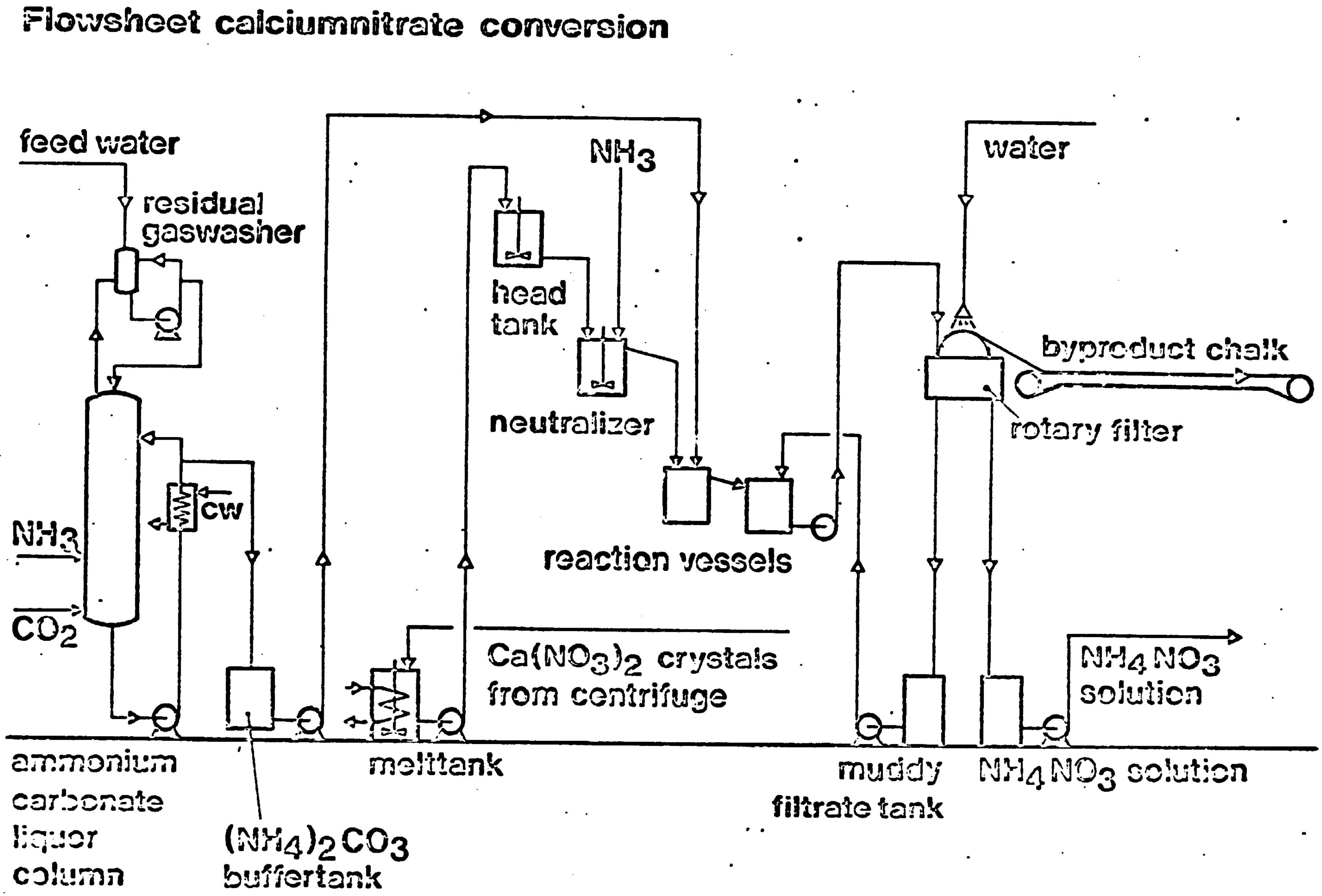


Figure 4


Flowsheet calciumnitrate conversion
feed water
residual gaswasher
NH_3
CO_2
cw
ammonium carbonate liquor column
$(NH_4)_2CO_3$ buffertank
melttank
$Ca(NO_3)_2$ crystals from centrifuge
head tank
NH_3
neutralizer
reaction vessels
water
byproduct chalk
rotary filter
muddy filtrate tank
NH_4NO_3 solution
NH_4NO_3 solution

BLOCK DIAGRAM SULPHATE RECYCLE ROUTE

Figure 5

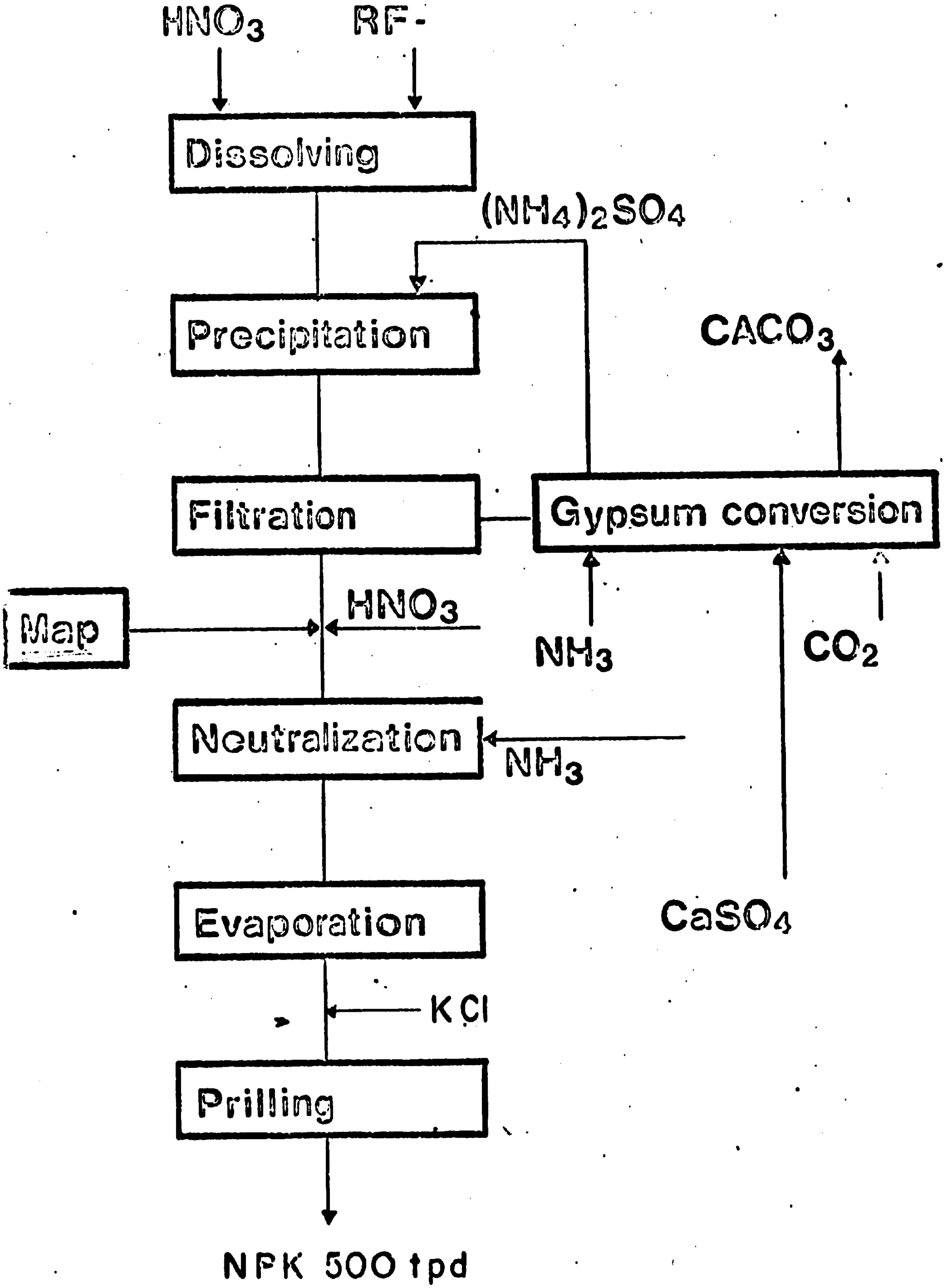


Figure 6

BLOCK DIAGRAM CRYSTALLIZATION PROCESS

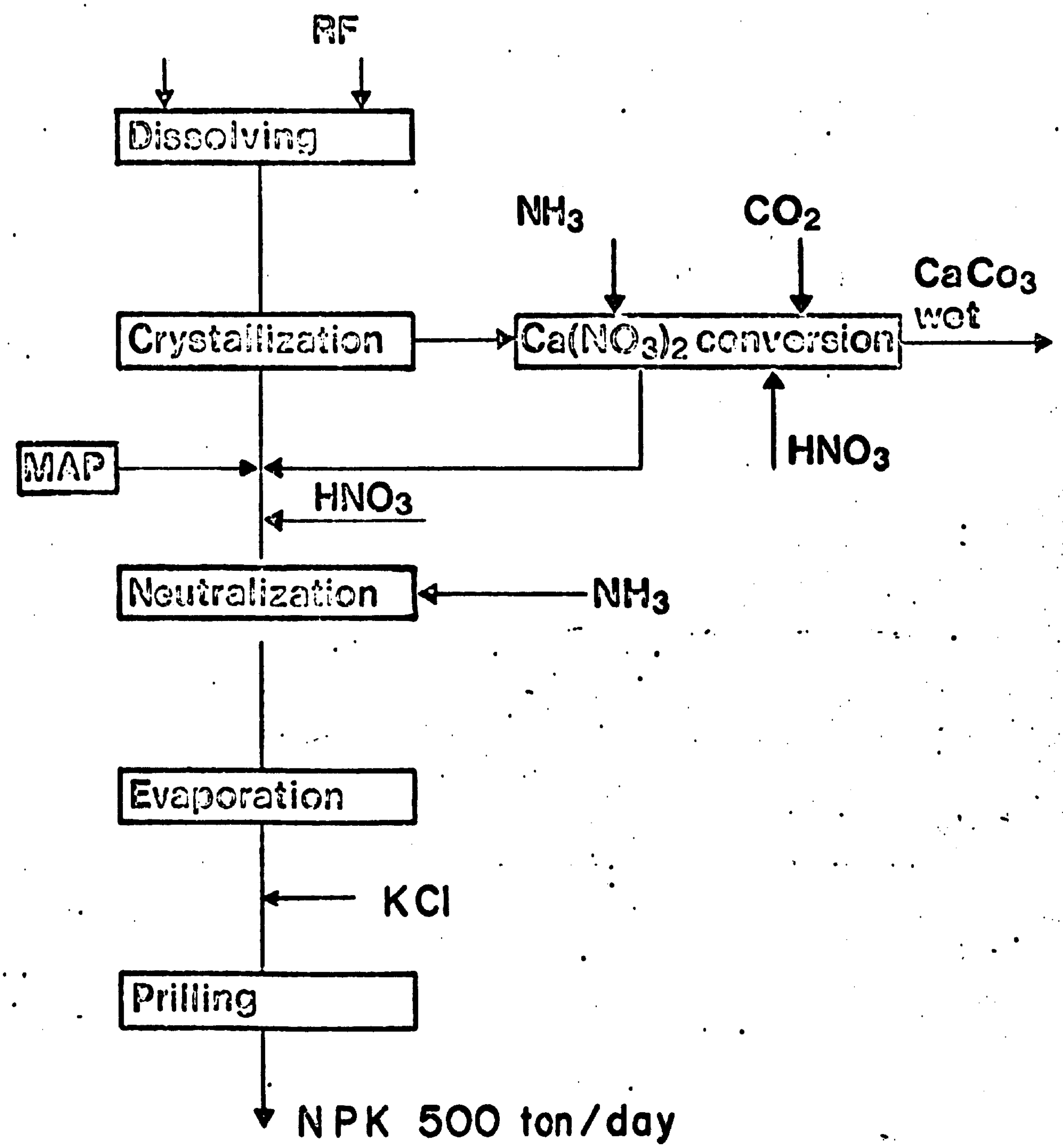
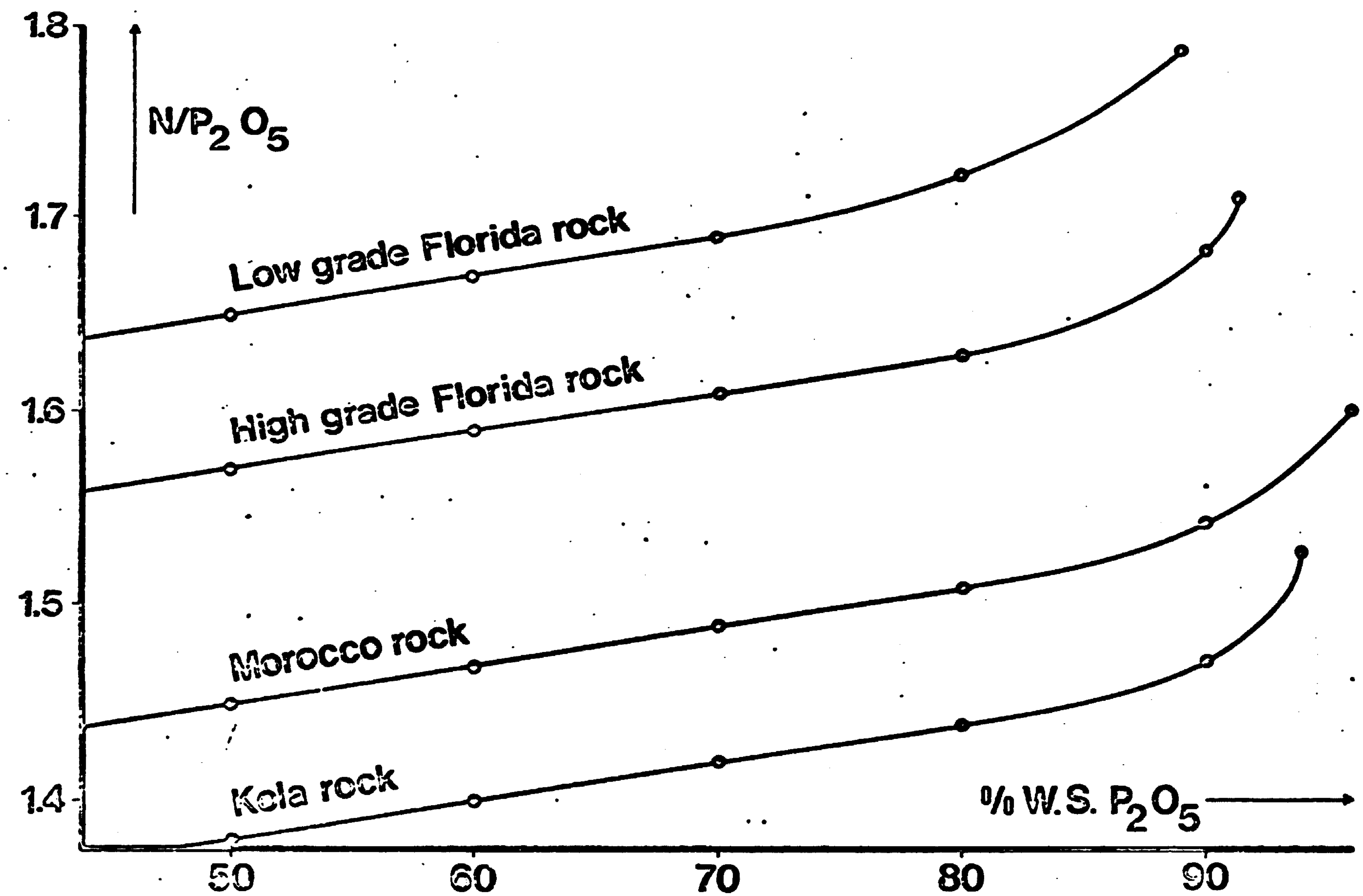


Figure 7



1.8
1.7
1.6
1.5
1.4
N/P2 O5
Low grade Florida rock
High grade Florida rock
Morocco rock
Kola rock
% W.S. P2O5
50
60
70
80
90

Fluid Fertilizers

As indicated in Chapter II, in the event demand is more than the anticipated maximum production of 500 tpd plant, as an alternative to increasing the capacity to 750 tpd, which no doubt would increase the economics of production of NPK fertilizers, resulting from the increase in scale of operation, manufacture of fluid fertilizer may be tried. The increase in the use of fluid fertilizer in the USA since 1960 has been remarkable. 1975 statistics indicated that 28% of all the fertilizer used in the USA was in the form of fluid mixed fertilizers. From 1959 to 1975 there has been 500% increase in the use of anhydrous ammonia, 700% increase in the use of nitrogen solution and a 600% increase in the use of fluid mixed fertilizers, mostly liquid and suspension of various NPK grades. In European countries also there has been significant increase in the use of fluid fertilizers. Between 1965 to 1970/71 increase in some of the countries has been:

	In Million tons of liquid		
	1965	1970/1971	Percent Increase
Denmark	0.037	0.160	432
France	-	0.414	264
Mexico	0.066	0.174	264
UK	0.094	0.219	233

In France the total tonnage of liquid fertilizer has increased to 600,000 tons in 1975/76, representing 10% of the countrie's fertilizer consumption, and in Denmark the use of anhydrous ammonia accounted for 45% of the share of nitrogen market.

Manufacture of ammonia and phosphoric acid, which are primary fertilizers cannot be avoided but converting them into solid form like urea, ammonium nitrate and solid phosphatic or NPK formulation requires considerable capital cost and energy, which are both very expensive these days. Production of liquid fertilizer require only half or even less energy than solid product. Transport of liquid fertilizer by pipe line over a distance of 300 km requires less than 1/4 the energy consumption by road transport, which is the main mode of transport in Central America and particularly in Honduras.

Major factors leading to the growth of fluid fertilizers in the USA and other developed countries are:

a) Cheapness in application, particularly because of high cost of labor and development of firms specializing in production and/or application of liquid fertilizer.

b) Uniformity of application.

c) The ease of preparation of wide variety of nutrient composition including micronutrient, trace elements, pertisides and herbisides etc.

Once the ammonia and basic facilities, even in limited quantities for Urea and ammonium nitrate (solution only) are available, manufacture of fluid fertilizer, to start with using imported phosphoric acid with formulation like 10-34-0 and 11-37-0 using TVA pipe reactor should not pose any problem. These solutions contain 65 to 80% of P_2O_5 as polyphosphate. TVA has made major contribution in the development of fluid fertilizers and particularly their recent development of pipe reacto-. which can produce high polyphosphate fluids from low-polyphosphate (20-30% content) wet process superphosphoric acid.

It would be worth installing, as an experimental major, a small pilot plant for manufacture of fluid fertilizer for areas of concentrated consumption like sugar cultivation or coffee cultivation in Sula Valley. If the experiment proves successful, similar plants can be installed at other locations. Exploratory inquiries reveal that a plant of standard capacity (15 t/Hr) including all necessary equipment for operation would cost about $100,000 to $150,000 for a cold mix plant and 175,000 to $250,000 for a hot mix plant. Part of the equipment, such as storage tanks etc, can be manufactured locally in Honduras (cost included in the above price). Because of the higher ambient temperature in Central America it is possible to produce more concentrated formulations.

Interest in the use of fluid fertilizers has developed lately in the developing countries like Algeria, Colombia, C.S.S.R., Cuba, Hungary, India, Iran, Morocco and Yugoslavia. Central America can get useful guidance from the experience of Cuba and Colombia. A list of formulations possible is attached at Annex I.

CHAPTER V

CAPITAL COST ESTIMATES

Capital cost estimates are based on the exploratory quotation from European sources. Being aware of the facts that cost of equipment and machinery prevalent in India, where substantial part of these items are locally manufactured would not be applicable to the Central American condition where, nearly the entire equipment and machinery would have to be imported, on my way to the duty station I took advantage of my passage through Europe to collect as much of the latest cost data as was possible. Since the nitro-phosphate complex fertilizer processes has been mainly developed and are being operated on commercial scale largely in Europe, the likely source of supply would mainly be Europe.

As indicated in Chapter II, a capacity of 500 tpd of NPK complex would be adequate for Honduras and the neighboring Central American countries Atlantic Coast. While considering this, it has been visualized that by limiting the number of formulations, it may be possible to attain an on stream efficiency of 300 days/ yr. With a capacity utilization of 95% it would be possible to attain an annual production of 142,500 tons of NPK which would be adequate on the basis of the forecast made on presently available date. In case, at the time a firm decision is taken and more reliable data is available and high capacity is considered necessary, quotations could be invited on the basis of the higher capacity,of say, 750 tpd., or quotations could be invited on two alternative basis 500 tpd and 750 tpd.

From the data currently available it has been noted that of the two latest processes described in Chapter IV, the sulphate recycle process requires less capital investment and the cost of production is comparatively cheaper. Agronomists generally are in agreement that water solubility of P_2O_5 of 80% is quite adequate for all crops and soils and higher water solubility is not necessary.

As already indicated in Chapter II, the most popular formulations is 15:15:15 or similar formulation with NPK ratio of 1:1:1. The process should, however, be flexible to produce other grades also. It is desirable to limit the formulations to as few as possible, consistent with the agronomic need of the crops, so that the plant down time loss (and in turn production loss) for changing formulation is minimum and capacity utilization is maximum.

Ocean Freight

Ocean freight for equipment transported from Europe/USA assessed by Mr. Alberty who was associating with me in collection of site date, etc.,with the help of local experts has been estimated as 6% and 5% of the FOB cost respectively. It is expected that most of the equipment would be bought in Europe. To cross check the freight I examined the freight estimated for some of the recent projects of FCI for the imported equipment (mostly from Europe). For these projects of FCI, the ocean freight works out to 6% of the FOB cost of the equipment. Even though freight indicated in the exploratory quotation is somewhat higher I have considered that a freight estimate of 6% of the FOB cost of equipment would be more realistic. Port handling and inland transportation has been estimated as 2% of the FOB cost, particularly as it is planned to locate the factory as near the port as possible.

Cost of civil works and erection of plant and machinery

The cost of civil works and erection in the exploratory quotations from European sources was working out to 40-45% of the FOB cost of the equipment. Discussions with firms like Gabinete Técnico, who are currently installing plants here, indicated that cost of labor and civil works material in Europe is about three times the costs prevalent in Central America, and, as per their experience of installing plants in Central America, the cost of civil works and erection of plant and machinery would be of the order of 20% of the landed cost. This has, therefore, been taken as a more realistic cost estimate.

Cost of off-site facilities

Attempts were made, without much success, to obtain the cost of off-site facilities and other auxiliary and support facilities required for normal operation of the plant. On the basis of information in the published literature as well as our experience for installing plants in India it was decided that this facilities would cost about 50% of the installed cost of the main plants.

On the above basis the capital cost of the complex plants based on Sulphate Recycle process, including gypsum conversion and the nitric acid plant of the required capacity has been estimated as indicated in table 2.

Besides the manufacturing facilities indicated above, expenditure on the following would need to be incurred.

Land:

Land required for the NPK plant would be about 100 acres. As suggested in Chapter II, it would be wise to make provision of installation of ammonia and urea plants either now or at a future date. Therefore, the total land requirement is estimated to be about 150 acres. It is understood the cost of land in this area is about Lps.695 acre. Therefore, cost of land would be about US$52,000. However, the main purpose of the installation of this factory is the industrial development of Honduras. The Government should, therefore, come forward and donate the land required for the factory free of cost.

Housing:

During normal operation of the factory about 250 personnels would be employed. During the construction stage the staff employed by the factory management and the contrator's staff engaged on the installation of the factory would be even more. Inquires reveal that no accommodation is available at Puerto Cortes or in the neighborhood and the nearest city with adequate housing is at San Pedro Sula, about 60 Km. away. Special housing programme would, therefore, have to be organized. Cost of building these houses should not be added to the project account and separate funds provided for this purpose, and the cost incurred should be gradually recovered in easy installments. Whereas, for lower category of staff it may be possible to find some houses in the nearby localities, accommodation may need to be provided for about 60% of the essential staff who may be working in shifts or may need to be called in emergencies. Thus about 150 houses may be required.

Spares for plant and machinery:

This is a very essential requirement to ensure that the plants are properly maintained and down time during break down/periodic preventive maintenance is minimum. The quantum of spares required would depend upon the operating conditions, how well the plants are operated and maintained and the lead time for procurement of spares. High inventory can have a very adverse repercussion on the cost of production as it is a blocked capital and at the present time cost of capital is very high. At the same time, any plant down time because of lack of spares would mean production loss and can do worse damage. Therefore, great care has to be taken while providing for the spare. For the time being, provision of spares to the extent of 5% of the cost of manufacturing facilities is considered reasonable. This can be reviewed and revised as more experience is gained from the operation of the plants, after the factory goes into production. Also encouraging establishment of ancilliary facilities in the neighborhood for manufacture/repair of commonly required item can be of great help in cutting down the cost of production of spare parts and the inventory and also provide employment to the local technicians.

Working capital:

To ensure uninterrupted working of the factory, certain minimum stock of raw materials, particularly imported, would be necessary. The quantity would vary depending upon the nearness of the source and lead time for procurement. Similarly adequate stock of process chemicals, catalyst, lubricants etc., would be required. Some of these items, including spares could be hypothecated to banks and easy credit arranged which would reduce the total capital requirements. Arrangement would also be necessary for credit from banking institution for payment of salaries, power and other requirements. For high value imported raw materials it may be wise to enter into long range annual contract and arrange of monthly (or in most economic lots) supply to cut down inventory to the minimum. With the help of the CABEI experts, on the basis of best practice followed in Central America, for the purpose of estimating the capital cost, initial working capital has been estimated as indicated in Annex II and has been taken as $2.755 m. For normal operation,working capital has been worked out to $5.008 m. as indicated in Annex III. As per the advise of CABEI experts, interest on the working capital has been estimated at the rate of 10.5% per annum.

Training expenses:

This being a new process/product key operational and maintenance staff would need to be provided training and necessary expenditure incurred for the same. The only place I can think of for this training facilities is STAMICARBON plant where the process has been developed or the other plant at Bulgaria being operated on similar processes.

Fertilizer Corporation of India has been having well organized training facilities since 1949 and have been providing training facilities for a large number of its own staff of various categories -craftmen, supervisors as well as executives. It has also been providing training facilities to other organization including staff from foreigh countries and their charges are, comparatively, extremely reasonable. Their plant at Trombay (Nr. Bombay) based on the crystallization process has already gone into production and the plant at Haldia (Nr. Calcutta) based on sulphate recycle process (precipitation process) is likely to go into production by mid 1978. Training expenses need not be capitalized and should be treated as deferred revenue. Expenditure on this item is difficult to estimate at this stage, but a tentative provision can be made of 0.1% of the total capital outlay.

Expenses incurred in seeding programme:

I have referred to the importance of seeding programme in Chapter II. The expenses incurred on this should also be treated as deferred revenue. Tentatively this may be estimated at approximately 1% of the total capital outlay.

Project management expenditure:

This would depend upon the method of execution (see chapter VII) adopted the extent of responsibility taken by the Project Management and the duration of project execution. However, a tentative provision of about 1.5% of the total cost of manufacturing facilities should be adequate for a reasonably well managed project.

Financing charges:

This is the interest on expenditure incurred during the construction stage and for supply and transport of equipment. This will depend upon the mode of financing of the project. This has been worked out by the CABEI Experts on the basis of 40% equity and 60% different categories of loans (as detailed in Annex IV) and works out to $1.743 m.

Contingencies:

Every item cannot be estimated very exactly. Besides there could be certain expenditure which cannot be foreseen at this stage. It would, therefore, be prudent to include a contingent expenditure of 10% of the estimated cost.

Escalation:

Even though inflation is, generally, under control, there is a tendency of increase in prices. In consultation with the CABEI and on their advice, escalation of 10% per year has been considered reasonable.

All the items, except the cost of manufacturing facilities, enumerated above has been discussed in detail with the experts of CABEI associated with the work and the estimate has been arrived at in full agreement with them.

TABLE 2.A

CAPITAL COST ESTIMATES

Capital of 16.5:16.5:16.5 NPK plant of 500 tpd capacity for a sulphate recycle process -precipitation-prilling route including the conversion of gypsum.

		Million Dollar
(a)	FOB cost of equipment including equipment, piping valves, instruments, electrical, insulation and engineering licence fees	3.635
(b)	Ocean freight	0.218
(c)	Unloading handling and inland transportation	0.073
(d)	Civil works and erection	0.785
	Total battery limit cost	4.711

Capital cost of 140 tpd (100% basis) nitric acid plant with combustion at 5 kg/cm^2 and absorption at 12 kg/cm^2.

		Million Dollar
(a)	FOB cost of equipment including piping valves instruments, electrical insulation and contractors	5.6044
(b)	Ocean freight	0.336
(c)	Unloading, handling and inland transportation	0.112
(d)	Civil works and erection	1.2105
	Total battery limit cost of NA plant	7.263
	Total manufacturing facilities including auxilliary and support facilities for nitric acid and NPK plant and total installation	17.961

TABLE 2-B

TOTAL PROJECT OUTLAY

		In Million Dollar
1.	Installed cost of NPK plant	4.711
2.	Installed cost of NA plant	7.263
3.	Cost of auxiliary and support facilities	5.987
4.	Total manufacturing facilities	17.961
5.	Cost of land 150 acres	Free gift
6.	Plant spares 5% of total cost of manufacturing facilities	0.898
7.	Working capital	2.642
8.	Financing charges	1.743
9.	Project management 1.5% of the cost of manufacturing facilities	0.269
	Sub total	23.513
10.	Contingencies at 10% of items 4 to 9	2.351
11.	Total capital outlay	25.864
12.	Escalation at the rate of 10% per yearof item 11	2.586
	Total capital requirement including escalation	28.45
13.	Deferred revenue	
	(a) Training 0.1% of item 11	0.0258
	(b) Seeding programme 1% of item 11	0.258
14.	Total capital requirement including escalation for one year	28.7338

CHAPTER VI

ESTIMATE OF COST OF PRODUCTION

Cost of production can be divided under two main heads (1) fixed cost and (2) variable cost. The main elements of fixed cost are the depreciation of plants and machinery, labor cost, cost of maintenance material, insurance cost, interest on working capital, and interest on short term and long term loans. Variable cost varies with the increase or decrease in production and is the cost of raw materials, utilities, catalysts and chemicals. It should be noted that so long as the electric power driven moving machinery remain in operation, power consumption does not change significantly with the change in production rate.

Coming to the fixed cost elements, the most important fixed cost element is the depreciation of plant and machinery -the cost of the manufacturing facilities. Each project has to form its own policy on depreciation consistent with the Internal Revenue Code prevailing in the country. Some countries revenue code provided for straightline method of depreciation while other countries provided for declining balance method. Even though the useful life of the plant and machinery could, depending on the quality of maintenance, be up to 20 years, to be safe it would be prudent not to assume a useful (productive and profitable) working life of more than 15 years. Many industries depreciate the machinery over a period of 10 years. To ensure that the high cost of fixed assets do not very adversely affect the cost of production, the modern practice followed by many industries in the developing countries is to depreciate the fixed assets on a straightline method over a period of 15 years, that is provide a depreciation at the rate of 6.67% per year, of the cost of manufacturing facilities.

Labor Cost

In consultation with the CABEI expert associated with the work, and in consultation with the senior executives of some continuously operated chemical industries locally, the staff requirements in different categories have been worked out. Salary scale for different categories have been given by the CABEI expert and is indicated in Table 3. The annual wage bill work out on the above basis is detailed in Table 4.

Maintenance Material

Cost of maintenance material is low in the beginning and gradually increase as the plant gets old. Extent of maintenance and consumption of maintenance material depends to a large extent, upon the care in operation and timely and proper maintenance of the machinery, and care in use of proper type and frequency of lubrication and correct alignment of the machinery as well as the quality of material used. Even though in the developed countries, where the maintenance material is readily available and cost not so high, general rule has been to make a provision of 3% to 5% of cost of manufacturing facilities for annual cost of maintenance material. In the developing countries where bulk of the maintenance material has to be imported, if proper care, as indicated above is taken, annual provision of 3% of the cost of manufacturing facilities should be adequate, at least for the first 5 years.

Insurance

To insure the plants against fire and other risk is a matter of policy. In case it is considered necessary to insure against such hazards,a provision of 0.5% of the cost of manufacturing facilities is the general practice followed. On the advise of the CABEI experts no provision has been made for insurance.

Annual cost of production on the above basis of fixed cost and the specific consumption of raw material, utilities and catalyst as indicated by the process designers (Annex IV-A and IV-B) has been workout to:

Annual production for NPK plant including gypsum conversion, has been worked out on the basis of 300 stream days, and for nitric acid plant on the basis of 330 S.D. Cost of production has been worked out on the basis of 80%,90% and 100% capacity utilization as detailed in Table 5. Costs of raw materials and utilities have been furnished by the CABEI experts associated with the work.

It is to be noted that no cost has been taken for CO_2 for gypsum conversion as the report has been prepared on the assumption that the complex plant will be integrated with ammonia urea plants and CO_2 would be a by-product. This aspect has been further detailed in the concluding chapter. No cost has been taken for coating agents, being insignificant.

TABLE 3

STAFF SALARY SCALES

1.	Special Executive	40,000 Lps./yr.
2	Executives	36,000 Lps./yr.
3.	Engineers Level I/Administrators Level I	24,000 Lps./yr.
4.	Engineers Level II/Administrator Level II	18,000 Lps./yr.
5.	Jr.Engineers/Jr.Administrator/Supervisor Level I	12,000 Lps./yr.
6.	Master workman Supervisor Level II Secretary Level I	7,200 Lps./yr.
7.	Skilled workers Secretary Level II	4,800 Lps./yr.
8.	Specialized worker Secretary Level III Typists, clerks	3,600 Lps./yr.
9.	Workers Security guards	2,800 Lps./yr.

TABLE 4

STAFF STRENGTH AND PAY ROLL

	Special Executive	Executive	Eng.L.I Adm.L.I	Eng.L.II Adm.L.II	Jr.Eng. Jr. Adm. Supervisor I	Mast.work Sup.L.II Sec.L.I	Skilled work. Sec.L.II	Spc.work. Sec.L.III Typist/clerk	Workers. Security Guards	Total Nos.
General Manager	1					1				2
Production (Including water treatment)		1	1		2	10	1 + 15	17	28	75
Maintenance		1					1			2
a) Plants + bagging			3		3	4	19	8 + 1	7	45
b) Shops (mech.elec, inst)						3	4	2	4	13
c) Boiler operation						5		5		10
Technical Services			1				1		1	3
(i) Management services				3	4					7
(ii) Laboratories				1	1	3				5
Material Management		1					1			2
a) Warehousing				1		2			4	7
b) Purchasing				1	2					3
c) Bagging and dispatch				1			10		3	14
Finance/Accounting		1		2	3		1	4		11
General Administration		1					1			2
a) Personnel			1	1			1			3
b) Public relation				1						1
c) Security					1				17	18
d) Gen.cleaning									6	6
e) Pool -Steno							2	3		5
-Typist/clerks								7		7
-Draftsmen							2	1		3
Contingencies				1	2	1	1	1		6
	1x40,000	5x36,000	6x24,000	12x18,000	18x12,000	29x7,200	60x4,800	49x3,600	70x2,800	250
Lps./yr	40,000	180,000	144,000	216,000	216,000	208,800	288,000	176,400	196,000	1,665,200
									=US$	832,600

TABLE 5

COST OF PRODUCTION

Items	Unit Cost $	80% Capacity 36960 MT NA+120,000 MT NPK Annual cons.	80% Capacity Annual cost $	90% Capacity 41580 MT NA+135,000 MT NPK Annual cons.	90% Capacity Annual cost $	100% Capacity 46200 MT NA+150,000 MT NPK Annual cons.	100% Capacity Annual cost $
Raw Material							
Ammonia	104/MT	22184 MT	2,307,136	24957 MT	2,595,528	27730 MT	2,883,920
Pt-Rd catalyst	6.9/gms.	6468 gms	44,629	6468 gms	44,629	6468 gms	44,629
Rock phosphate	53/MT	26280 MT	1,392,840	29565 MT	1,566,945	32850 MT	1,741,050
M.A.P	156/MT	22560 MT	3,519,360	25380 MT	3,959,280	28200 MT	4,399,200
KCl	72/MT	33600 MT	2,419,200	37800 MT	2,721,600	42000 MT	3,024,000
Make up gypsum	13/MT	4920 MT	63,960	5535 MT	71,955	6150 MT	79,950
Utilities							
Steam	3.25/MT	95904 MT	311,688	107,892 MT	350,649	119880 MT	389,610
Elec. power	0.02/KWH	6.2427 m Kwh	124,854	6.2427 m Kwh	124,854	6.2427 m Kwh	124,854
Cooling water	0.013/M^3	11.018 m M^3	143,239	12.396 m M^3	161,144	13.773 m M^3	179,049
Fuel oil	1/MT NPK	120,000 MT	120,000	135,000 MT	135,000	150,000 MT	150,000
Other Expenditure							
Consumable stores			305,330		343,490		381,660
Baggs	15/MT		1,800,000		2,025,000		2,250,000
General expenses and contingencies			610,650		686,980		763,300
Maintenance material			538,830		538,830		538,830
Labor and overheads			832,600		832,600		832,600
Annual works cost			14,500,430		16,141,560		17,782,690
Interest on working capital			420,710		473,300		525,890
Depreciation			1,197,998		1,197,998		1,197,998
Annual cost of Production			16,119,138		17,812,858		19,506,578

CHAPTER VII

PROFITABILITY

Profitability of the project has been worked out under different alternatives. According to the information furnished by Mr. Alberty, the ex-factory price of 15:15:15 FERTICA product is $148.81. The product to be produced by the process employed under this feasibility study, and with the raw materials and utilities assumed, would give a product of higher nutrient contents, that is 16.5:16.5:16.5 -a nutrient content of 49.5%, as against the nutrients contents of 15:15:15 product being 45%. The product is, therefore, 1.1 times more concentrated than 15:15:15 for which the ex-factory price is $148.81. Therefore, the selling price of 16.5:16.5:16.5 has been taken as $163.69/MT.

In the January/February 77 issued of "Nitrogen" the FOB price of 15:15:15 available in open market has been indicated as $110 to $115 per MT. This product if imported from Europe/U.S.A., would have to bear,besides the FOB prices additional charges of $ 12.00 freight and $ 6.00 handling and port charges at Cortes, resulting in a landed cost of $ 133/MT for a product costing $ 115 FOB. Multiplying by a factor of 1.1, the price of a comparable product would be $146.3/MT. Therefore, profitability has been worked out on two alternative selling prices (1) with an ex-factory price of $163.69/MT and (2) with an ex-factory price of $146.3/MT.

Since it may not be possible to achieve a production level of 100% capacity utilization soon, profitability has been worked out at 100% production level, as well as 90% production level. A plant well designed and operated by well training staff,it whould be possible to achieve a capacity utilization of 90% within the second year of operation under very good conditions, or at least in the third year of operations. For the purpose of profitability, selling and administrative expenses has been taken as 2.5% of the sales realization at 100% capacity under alternative (1). Under this condition the selling and administrative expenses works out to $ 613,837. Profitability has been worked out on the basis of:

(1) Return on total capital outlay of $25.864 million, which is the capital employed before escalation and excludes deferred revenue as indicated in the Table 2.B. These factors have been excluded because if the escalation factor of 10%/year is included the same escalation should, naturally, be applied to the sales price also. Deferred revenue indicates the expenditure on training and seeding programme which has to be recovered, in due course from the sales proceedings and is normally not capitalized. Even though for the purpose of total capital requirement for a project, which may materialized after a year or so, these items have a significance, but since other expenditures, as well as raw materials and utilities has been taken at the current price levels, it would be reasonable to work out the return on capital as it would be incurred excluding these factors.

(2) For return on equity, as per the advice of CABEI experts associated with the work, 40% of the capital has been taken as equity and 60% as loans

of different categories as indicated in the Chapter V and Annexure IV.

The profitability under these alternatives is detailed in Table 6-A and 6-B.

Break even point has also been worked out under two different alternatives with the selling price of \$163.69/MT and \$146.3/MT and is detailed in Tables 7-A and 7-B.

Pay-back period has been worked out and is detailed in Table 8.

From the above consideration, it would be noticed that, in spite of all the raw material and equipment being imported this is an extremely viable and attractive project with a return on equity of as high as 27.1% under best conditions. Even under the worst condition of international competition it should be possible to earn a minimum return on capital employed of 7.05% and return on equity of at least 2%, which should be a very rare case. With a break even of about 42% and a pay-back period of just 6.35 yrs., this should be very favorably comparable with any of the existing fertilizer units.

TABLE 6-A

PROFITABILITY ANALYSIS. ALTERNATIVE A

Sales Price $163.69/MT

	90% Production level 135,000 MT/Annum $	100% Production level 150,000 MT/Annum $
Annual sales realization	22,098,150	24,553,500
Annual cost of production	17,812,858	19,506,578
Selling and administration expenses	613,837	613,837
Net profit before interest on borrowing	3,671,455	4,433,085
Total capital employed	25,864,000	25,864,000
Return on Capital Employed	14.2%	17.14%
40% equity and 60% loan and interest on loan at 10.5%	1,629,432	1,629,432
Profit after interest on borrowing	2,042,023	2,803,653
Equity	10,345,800	10,345,800
Return on Equity	19.74%	27.1%

TABLE 6-B

PROFITABILITY ANALYSIS. ALTERNATIVE B
Salling Price $ 146.3/MT

	90% Production level 135,000 MT/Annum $	100% Production level 150,000 MT/Annum $
Annual sales realization	19,750,500	21,945,000
Annual cost of production	17,812,858	19,506,578
Selling and administration expenses	613,837	613,837
Net profit before interest on borrowing	1,323,805	1,824,585
Total capital employed	25,864,000	25,864,000
Return on Capital Employed	5.12%	7.05%
40% of equity and 60% loan interest on loan at 10.5%	1,629,432	1,629,432
Profit after interest on loan	-305,627 (loss)	195,153
Equity	10,343,800	10,343,800
Return on Equity	-	1.89%

TABLE 7-A

BREAK EVEN POINT. ALTERNATIVE I
Selling Price of $163.69/MT

Variable Cost (V) (At 100% capacity, from Table 5)	
Raw materials	$ 12,172,749
Utilities	$ 843,513
Other variable expenses	$ 3,920,850
Consumable stores	
Baggs	
Interest on working capital	
Contingencies	
Total of (V)	$ 16,937,112
Fixed Cost (F)	
Labor and overhead	$ 832,600
Maintenance material	$ 538,830
Selling and Adm.expenses	$ 613,837
Depreciations	$ 1,197,998
Total of (F)	$ 3,183,265
Annual Sales Realization (R) (At 100% capacity, from Table 6-A)	$ 24,553,500

Break Even $\frac{(F)}{(R - V)} = \frac{3,183,265}{7,616,388} = 41.79\%$

TABLE 7-B

BREAK EVEN POINT. ALTERNATIVE II

Selling Price of $146.3/MT

In this case V and F remain same as for Alternative I.

Only Annual Sales Realization changes.

In this case Break Even workout to:

$$\frac{3,183,265}{21,945,000 - 16,937,112} = 63.56\%$$

TABLE 8

PAY BACK PERIOD

Total Capital (Including escalation and Deffered Revenue)	$ 28,733,800
Annual realization	$ 24,553,500
Annual work cost	$ 17,782,690
Selling and Adm. expenses	$ 613,837
Interest on borrowings	$ 1,629,432
Net surplus cash at hand	$ 4,527,541
Pay back period	6.35 yrs.

CHAPTER VIII

MODE OF IMPLEMENTATION

There are number of ways of implementation of a project such as:

(a) Cost plus basis

(b) Turn-key contract

(c) Splitting the work between different agencies, each one of which is most suited and specialized for the particular job and can execute the job most expeditious and most economically.

Each of these methods have its merits and demerits.

(a) Cost plus basis

In this system, the job is entrusted to one or more specialized agencies on cost incurred plus certain percentage of the cost incurred as commission for the agency. This system has a tendency, generally, of cost increasing as it is difficult to provide a check on the cost incurred and there is no incentive/deterrent for the contractor to cut down the cost or keep it under control. This system, however, has an advantage where it is difficult to correctly specify the job, there are changes or variations in the quantum or nature of job during the course of execution, or if the job is being executed under such conditions that no one, or more, contractors are able to assess the nature and quantum of job and are willing to take up the job.

(b) Turn-key contract

Turn-key type of contracts are very common and has the advantage that one party is responsible for executing the entire job and, if proper contractor is selected, all the variables fully defined and contract can be made very exact and rigid, the job can be executed very expeditiously and the owner's overheads can be minimum. However, under the conditions prevailing in the developing countries, it is difficult to find a contractor from the developed countries, who is fully aware of all the conditions prevailing in the country and to ensure that he is not at a loss, he has to provide adequate margin of safety. Also, labor cost in most of the developed countries is comparatively high and many jobs, which can, otherwise, be executed in a cheaper manner, are assessed at a much higher cost by the contractor from the developed countries. Besides, it is very difficult to make any contract very specific, and tie the contractor very rigidly, and at the same time make it workable, that many loopholes are inevitable and the contractor finds it very easy and convenient to get out of his responsibility.

(c) Splitting the work between different specialized agencies.

This mode, even though may have some drawbacks is, these days, being generally adopted by India and many other developing countries. Process know-how and the basic design has got to be entrusted to the parties in the developed countries who have developed the process and are the only one competent to do this job. Detailed process designing, detailed engineering and drafting can more economically be entrusted to organizations in the developing countries where man power is cheaper and the contractor need provide only limited supervision to ensure that his design is being correctly followed and implemented. On the basis of these detailed drawings and specifications, the procurement can be done either by the owner or the party doing detailed engineering. Needless to mention, to ensure that the main contractor's ideas are being correctly followed and implemented and he is unable to shirk his responsibility, one of his specialist is associated with every critical stage of the work. India has three designing organizations. -Engineers India Lts., FEDO (Fertilizers and Engineering Design Organization -a subsidy of Fertilizers and Chemicals, Travancore) and Planning and Development Division of the Fertilizer Corporation of India, which is executing a very large portion of its own jobs since 1955, and have, for last ten years been doing similar jobs (including complete process design in many cases) for outside parties also. It is likely that other more developed among the developing countries like Brazil, etc., may have similar organizations and facilities.

Similarly, jobs like civil work and erection of plant and machinery can, more economically be entrusted to some local or outside parties established here and doing similar jobs (refer Chapter V).

Besides being comparatively cheaper this mode of execution has the advantage that it helps developing local technical talent and, in due course, local staff would be able to execute more and more of the job themself and help in making the country technically self-sufficient. Even if this mode proves to be, marginally more expensive, this is a very important aspect and cannot be ignored.

In this connection, it would be worthwhile to reproduce an abastract of an article "First thing first -at last" by Mr. Peter Adamson appearing in September-October 1977 issued on UNDP News.

> "...lack of participation by the poor themselves has so far been the 'missing link' which has broken the chain between the international development effort and the poorest 40% of the Third World's people".

> "Its possible and realizable consequence would be that a development effort based on workers who are chosen 'of the people, by the people, for the people' would ensure that the poor themselves participate in the process of their own development. It also makes it more likely that those who serve them in that task will be responsive to local needs and priorities; sensitive to local traditions and feelings; knowledgeable about local skills and resources; accepted and trusted by, and ease and familiar with, the people with whom they work - factors absent in much previous development work".

Mode of execution has, at times, to be modificed to suit the financing arrangement and often institutions like World Bank, Ex-Imp Bank, Supplier's credit etc., decide and effect the mode of execution.

CHAPTER IX

PROJECT SCHEDULE

In Chapter II (Page 9) a tentative indication has been given of the project execution schedule. Time schedule has been worked out taking into consideration the establishment of ammonia-urea production facilities also on the basis of project execution experience in India and the experience of many other developing countries. This is considered a reasonable and practical time schedule; and if the plant is immediately taken up for execution, as indicated in Chapter II (Page 9) it is likely to take about 4 1/2 years on the average for the commissioning of the plant, and the plant is likely to go into production by January 1984.

The production level for the first, second, third and fourth year of production has been taken at 50%,70%,80% and 90% respectively.

In the event it is intendednot to install ammonia-urea facilities, for which even the initial work for preparation of the feasibility report has yet not been taken up, there may be some reduction in the design engineering period and also marginal reduction in installation and commissioning. Under these circumstances, it may be possible to have an overall reduction of about one year in the project time schedule indicated at Page 9, and it may be possible to commision the plan in January 1983.

Elimination of ammonia-urea facilities would, however, increase the capital cost indicated in Chapter V and would adversely affect the economics of operation. This has been dealt with in somewhat greater detail in the concluding Chapter.

CHAPTER X

NATIONAL BENEFITS

The normal commercial method of examining the benefits of industrial establishments, particularly, by private concerns is the commercial profitability determined by various methods including return on capital employed, return on equity, pay back period and internal rate of return, using discounted cash flow method.

The major advantage of the criterion of commercial profitability is that it is an objective criterion. Nevertheless, it is clearly not the best measure to evaluate industrial projects from the national point of view. Normally there are significant divergencies between commercial profitability and profitability in terms of national economic development. Such divergencies arise because the criterion of commercial profitability cannot take into account the external effects of projects and because social rates of discount, reflecting the community's preference for present or future consumption, may differ from private rates of discount, and especially from private foreign rates of discount. It has been advocated, therefore, that the proper criterion to use is that of national economic profitability.

In this respect it would be useful to refer to a few selected extracts from UNIDO's monograph on industrial development (monograph 17, published in 1969).

Since a major shortcoming of the evaluation of projects in terms of commercial profitability is that it fails to take account of external effects, social benefit-cost analysis must of necessity attempt to do so. The external effects of projects can include both costs and benefits. Among the principal external benefits resulting from industrial projects are the formation of a skilled labor force and the acquisition of technical know-how.

As defined by A.K. Sen, "social benefit-cost analysis" is essentially a tool to formulate and evaluate projects in terms of the explicit national objectives that underlie development planning.

> " The social benefit-cost analysis tackles tactical questions at a project level of the product mix, the size of the plant, its location, the choice of technological processes, the use of different raw materials, factor proportions, the degree of specialization, opportunities for future expansion, time phasing, etc., so that projects are formulated and evaluated in order to fulfill the objectives of the over-all plan, including the sectoral programmes".

Any project will have indirect effects because it causes changes to take place in the rest of the economy. The effect on the demand and supply of goods produced in other industries should be taken into account in the evaluation of the project.

As indicated in Chapter I, fertilizer plant could be the nucleous for the development and growth of chemical industry in the country. Around the fertilizer factory there would be tremendous scope for development of ancilliary/auxilliary industries based on by-product, co-product and other feeder industries to meet the requirements of the fertilizer complex.

In the event ammonia-urea facilities are also integrated, there would be considerable scope for establishment, in due course, of methanol manufacturing facilities, which has, more or less, identical technology and methods of operation and formaldehyde manufacturing facilities which are essential for manufacture of resines required for playwood industry, for which there is a tremendous scope in Honduras. In the event it is decided to establish fluid fertilizer facilities and establish facilities for manufacture of phosphoric acid, there would be scope for manufacture of calciumfluoride, sodiumfluoride and cryolite based on by-product hidrofluorsilicic acid which would be a by-product in the manufacture of phosphoric acid. These items are essential for many industries and could also be a source of foreign exchange earning. Also the by-product gypsum could be used for production of wallboard and insulating boards. Also gypsum could be used for direct application for certain crops and certain soils where sulphur is required as a micronutrient.

Manufacture of fertilizer and its associated auxilliary/ancilliary industries as well as the selling and marketing organization of the fertilizer industry and its agents/distributors would provide employment to thousand of people and thus help erradicating unemployment in the country.

SUMMARY

1. The very basis of this prefeasibility report is the recommendation of the SIECA report. The SIECA has recommended 29 alternatives grouped in 7 different patterns. All the alternative recommended are integrated with ammonia urea manufacturing facilities Their analysis has proved that the nitric acid acidulation process is cheaper as compared to sulphuric acid acidulation process. I am in full agreement with this basic recommendation. Under item 7 of my terms of reference, I have been asked to examine only NPK complexes and prepare a prefeasibility report for NPK complex only. Fertilizer industry has to be examined as a whole and separation of NPK complex from ammonia-urea manufacturing facilities does not appear to be a scientific approach. At Vienna, at the time of briefing, I was given to understand that as a follow-up mission ammonia/urea facilities would be established and UNIDO is looking for an ammonia/urea expert. In this connection, I am reproducing paragraph (h) of the briefing note dated 3rd August 1977 circulated by Mr. C. Keleti.

> " The expert was informed about the follow-up mission requested by CABEI on the viability of establishing two large ammonia/urea plants to serve the Central American countries. This project for which advanced recruitment action has been taken by UNIDO, will be implemented as soon as all the funds become available. An overlap between the experts (Mr. Kachwaha) mission and the follow-up mission of at least two weeks appears desirable and UNIDO will take action immediately on this matter".

2. Even as early as February 17, 1977 while finalizing the "Memo of Understanding" installation of ammonia-urea manufacturing facilities was

anticipated. The memo very unequivocally stresses "As a follow-up of the SIECA study on fertilizers, CABEI needs the services of an expert in ammonia-urea. The draft job description presented by Mr. El Halfway represents the needs of CABEI to promote the establishment of ammonia-urea industry in Central America".

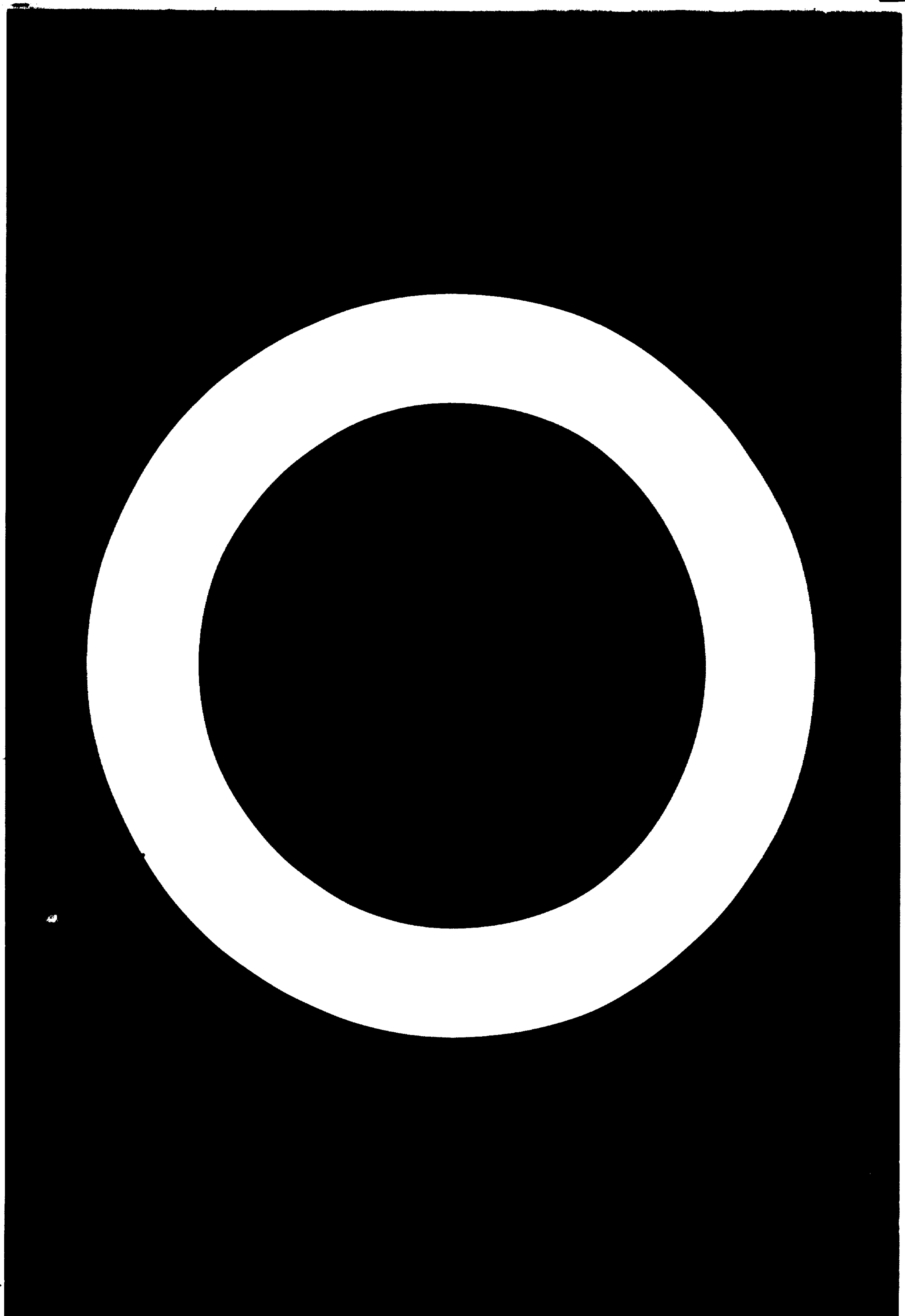
3. It has, therefore, been presumed that sooner or later, rather sooner than later, ammonia/urea manufacturing facilities would be established. It would be better if these facilities are established simultaneously. In the absence of ammonia/urea facilities availability of CO_2 in adequate quantities may pose a problem, and unless by-product ammonium sulphate (from caprolactum plant or cake oven plant, which I understand does not exist in Central America), is available, it will become necessary to resort to use of sulphuric acid for manufacture of ammonium sulphate which would increase the cost and may adversely effect the economics.

In the event the plant is not integrated with ammonia-urea manufacturing facilities and no arrangement is possible for supply of CO_2, at the rate of 0.075 tons/ton (100% basis) of the product, it would be necessary to put up facilities for producing about 100 tpd of ammonium sulphate (100% basis -as 38% sol.) and necessary sulphuric acid facilities, as well as, facilities for storage of about 10,000MT of ammonia and necessary refrigeration, pumping, unloading and piping facilities at additional cost which is not included in the present estimate. Cost of these facilities can be obtained from the recent installation at FERTICA's Puntarenas Plant.

4. The main deviation from SIECA recommendation is location of the fertilizer factory in Honduras for which adequate justification has been given in Chapter I.

5. Even though adequate statistics are not available, from the discussions with the executives of the organized agricultural sector and their forecast for the near future, there is sufficient justification for a plant of, at least, a capacity of 500 tpd of 15:15:15 grade NPK. The plant would, of course, be flexible to produce other grades also. If the requirements of the entire Alantic Coast of Central America including Belize and the Caribbean Islands is taken into consideration it may be possible to even justify a capacity of 750 tpd NPK plus one or more fluid fertilizer plants at selected locations.

6. The location of the factory near Puerto Cortes has been considered ideal from consideration of the best developed port for the import of raw material and equipment as well as the market.



ANNEX I

FORMULATIONS FOR LIQUID FERTILIZERS

Ratio	Grade	10-34-0 kg	UAN 32% N kg	KCl 62% kg	H2O kg	Salting out temp. °C Calcul.	Determ.
1:1:0	16-16-0	470	353	-	177	-3.3	-3.3
1:2:0	13-26-0	765	167	-	68	-7.8	-
1:3:0	10-30-0	883	36	-	81	-17.8	-
1:1:1	8- 8-8	236	126	129	459	+5.0	+0.6
1:2:1	8-16-8	471	102	129	198	+2.8	-10.0
1:3:1	7-21-7	618	25	113	244	-11.1	-11.1
1:1:2	5- 5-10	147	111	161	581	-6.7	-
1:2:2	5-10-10	294	65	162	479	-7.8	-
1:3:2	5-15-10	441	19	162	378	+6.7	+2.2
1:1:3	4- 4-12	117	89	194	600	-6.7	-
1:2:3	4- 8-12	236	51	193	520	0.0	+6.1
1:3:3	3- 9-9	264	11	145	580	+18.0	-
2:1:0	20-10-0	294	533	-	173	+18.0	-
2:1:1	10- 5-5	147	266	80	507	0.0	-
2:2:1	10-10-5	294	222	80	404	0.0	-7.8
2:3:1	10-15-5	441	175	80	304	-5.0	-
2:4:1	10-20-5	588	130	80	202	+1.7	-
2:1:2	6- 3-6	88	161	97	654	-7.8	-
2:3:2	8-12-8	353	140	129	378	0.0	-
2:1:3	6- 3-9	88	161	145	606	-2.8	-
2:2:3	6- 6-9	176	133	145	546	0.0	-
2:3:3	6- 9-9	265	106	145	484	0.0	-
3:1:0	21- 7-0	206	592	-	202	+18.0	-
3:2:0	18-12-0	353	453	-	194	+18.0	-
3:1:1	12- 4-4	118	339	64	479	-2.2	-
3:2:1	12- 8-4	235	302	64	399	0.0	-
3:3:1	12-12-4	353	266	64	307	0.0	-
3:4:1	12-16-4	471	228	64	237	0.0	-
3:1:2	9- 3-6	88	254	97	561	0.0	-
3:2:2	9- 6-6	176	227	97	500	+2.2	-
3:3:2	9- 9-6	264	200	97	439	+2.2	-
3:1:3	6- 2-6	59	169	97	675	-7.8	-
3:2:3	6- 4-6	117	152	97	634	-7.8	-
4:1:0	24- 6-0	177	695	-	128	-6.7	-
4:1:1	12- 3-3	88	349	48	515	-7.8	-
4:2:1	12- 6-3	176	321	48	455	-7.8	-
4:3:1	12- 9-3	265	292	48	395	-7.8	-
4:4:1	12-12-3	353	266	48	333	-5.0	-
4:1:2	8- 2-4	59	232	64	645	-10.0	-
4:3:2	8- 6-4	176	196	64	564	-12.8	-
4:1:3	8- 2-6	59	231	97	613	0.0	-
4:2:3	8- 4-6	117	214	97	572	0.0	-
4:3:3	8- 6-6	176	196	97	531	-2.2	-
4:4:3	8- 8-6	236	176	97	491	-2.2	-
4:3:4	8- 6-8	176	196	129	499	+4.4	-

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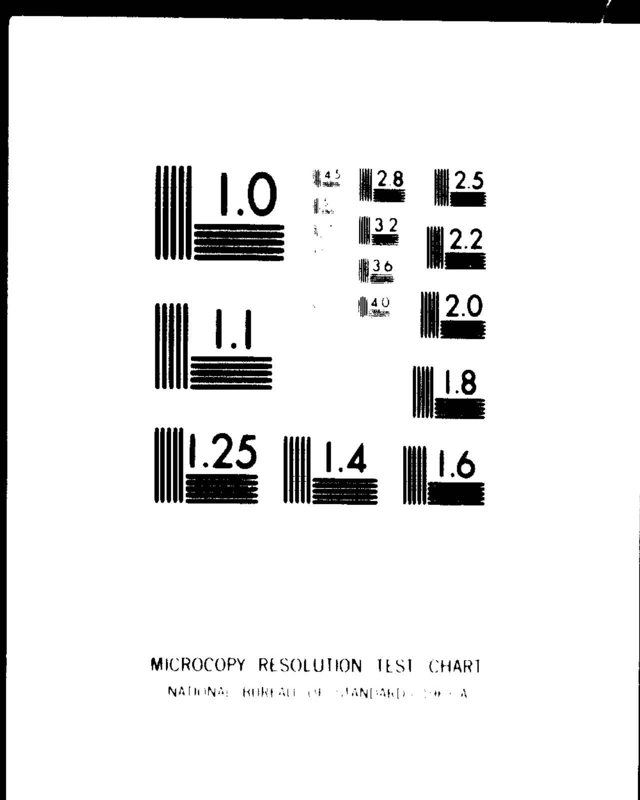

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ANNEX II

INITIAL WORKING CAPITAL

Requirement of Raw Material and other consumable stores for Commissioning period (On the basis of production level of 50%)

1.	Ammonia for nitric acid -3 months	90x70x0.282x$104	=	$184,800
	Ammonia for NPK plant -3 months	90x250x0.1x$104	=	$234,000
2.	Rockphosphate -3 months	90x250x0.219x$53	=	$261,200
3.	M.A.P. -3 months	90x250x0.188x$156	=	$659,900
4.	KCl -3 months	90x250x0.280x$72	=	$453,600
5.	Gypsum -1 month	30x250x0.041x$12.78	=	$ 3,930
6.	Pt-Rd catalyst -3 months	90x140x0.14 gmx$6.9	=	$ 12,172
7.	Elec.power -2 months (nitric acid)	60x140x8.5 kwhx$0.02	=	$ 1,430
8.	Elec. power -2 months (NPK)	60x500x39 kwhx$0.02	=	$ 23,400
9.	Fuel oil -2 months	8500x15 kcl/t x60x300x$1'0	=	$ 18,000
10.	Packing material -1 month	250x30x$15	=	$112,500
11.	Bulk product -10 days at 50% of capacity	2500x$135/MT	=	$337,500
	Bagged product -5 days	1250x$150/MT	=	$187,500
12.	Staff salary -2 months		=	$139,000
	Total initial working capital	$2,628,900		
	Miscellaneous consumable stores and contingency 5%	$ 125,800		
	Total	$2,754,700		

ANNEX III

NORMAL WORKING CAPITAL

(At 100% capacity for nitric acid and NPK plants)

Inventory of Raw Material, consumable stores, utilities and staff salary

1.	Ammonia for nitric acid -90 days	90x140x0.282tx$104	=	$ 369,500
	Ammonia for NPK plant -90 days	90x500x0.1 tx$104	=	$ 468,000
2.	Rockphosphate -90 days	90x500x0.219 tx$53	=	$ 522,300
3.	M.A.P. -90 days	90x500x0.188 tx$156	=	$1,320,000
4.	KCl -90 days	90x500x0.280 t x$72	=	$ 907,200
5.	Gypsum -30 days	30x500x0.041 t x$13	=	$ 8,000
6.	Pt-Rd catalyst -90 days	90x140x0.14 gm x $6.9	=	$ 12,200
7.	Elec.power -2 months NA	60x140x8.5 kwh x $0.02	=	$ 1,430
8.	Elec. power-2 months NPK	60x500x39 kwh x $0.02	=	$ 23,400
9.	Fuel oil -2 months	8500x15 kcl/t x 60x500x $1.0	=	$ 30,000
10.	Baggs for packing	30x500x$15	=	$ 225,000
11.	Bulk product -10 days	10x500x$135/MT	=	$ 675,000
12.	Staff salary -3 months		=	$ 208,000
	Total			$4,770,000
	+ Contingencies and miscellaneous stores 5%			$ 238,500
		Total		$5,008,500
		Interest at 10.5%		$ 525,892

ANNEX IV-A

CONSUMPTION FIGURES

Per metric ton HNO_3	100%
Ammonia	282 kg
Electric power	8.5 kWh
Platinum	0.14 g
Cooling water	165 m^3
Process water	0.3 m^3
LP heating steam	0.1 t

STEAM GENERATION

HP export steam	0.2 t

ANNEX IV-B

Production and consumption figures per ton of end product for a precipitation-prilling route including the conversion of $CaSO_4$

Capacity	500 tons/day
Product quality:	
% N	16.5
% P_2O_5	16.5
% K_2O	16.5
% H_2O	<1.0
% rel.water.sol.P_2O_5	86.9
Phosphate rock (Florida: 33.12% P_2O_5)	0.219 ton
Ammonia (as 100%)	0.098 ton
Nitric acid (as 56%)	0.550 ton
Carbon dioxide (as 100%)	0.075 ton
M.A.P. (12-52 and 2% H_2O)	0.188 ton
KCl	0.280 ton
Make.up gypsum ($CaSO_4$ 2aq)	0.041 ton
Coating agent:	
Clay	0.013 ton
Oil amine	0.002 ton
Steam 4 ats.abs.	0.04 ton
Steam 7 ats.abs	0.35 ton
Steam 15 ats.abs.	0.44 ton
Cooling water	40 m^3
Process condensate	0.26 m^3
Filtered river water	0.66 m^3
Electricity (expected)	39 kWh
Fuel gas (8500 kcal/Nm^3)	15 Nm^3

ANNEX V

Officials interviewed(November 7-23, 1977) -Tegucigalpa/San Pedro Sula

1. Mr. Rodolfo Alvarez Baca, Vice President COHBANA
Mr. Guillermo Sevilla, COHBANA (Honduras Banana Corporation), Tegucigalpa, Honduras.

2. Mr. Jorge A. Coello, Operations Manager, Standard Fruit Company, Tegucigalpa, Honduras.

3. Lic. Oscar Castro T., Aguan Valley Development Project, Tegucigalpa, Honduras.

4. Ing. Roberto Gálvez B., Industrial Projects Promotion Officer, Corporación Nacional de Inversiones, Tegucigalpa, Honduras

5. Ing. Manuel Osorio Milla, Technical Assistance Program, Cooperativa Agropecuaria Algodonera del Sur, Ltda., Tegucigalpa, Honduras (Cotton Growers Cooperative)

6. Mr. Héctor Callejas V., Vice President, Central Bank of Honduras. Tegucigalpa, Honduras.

7. Mr. Donaldo Suazo, General Manager and Mr. J.J. Herrera, Technical Director, Compañía Azucarera Hondureña, San Pedro Sula, Honduras.

8. Mr. A. Hepburn, General Manager, Cementos de Honduras, S.A., Bijao, Cortés, Honduras.

9. Dr. R.H. Stover, Director of Research, United Fruit Company, La Lima, Cortés, Honduras.

10. Mr. Edgardo Paredes, Empresa Nacional Portuaria, Puerto Cortés, Honduras.

11. Mr. H. Madrid, Deputy Director, Agriculture Operations Development, Ministry of Natural Resources, Tegucigalpa, Honduras.

12. Mr. Roberto Ruiz, Lic. Luis Alberto Tenorio M., Ing. Abraham Espinoza, Agriculture Division, National Planning Board.

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