PART III

FERTILIZER INDUSTRY AND RAW MATERIALS AVAILABILITY IN THE REPUBLIC OF ARGENTINE

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CHAPTER 1. INTRODUCTION

This Part of the report describes the present situation of the fertilizer industry, the potential availability of various raw materials used for the fertilizer production and the fertilizer quality standards and regulations in the Republic of Argentine, all of which constitute a fundamental part of the subsequent technical and financial study of the proposed phosphate fertilizer project.

In regard to the national production of three basic fertilizer nutrients that are nitrogen, phosphorus and potash, a considerable production is reported only for the nitrogen; ammonia, urea, nitric acid, ammonium nitrate and ammonium sulfate are now being manufactured starting from natural gas available in the country. The volume of domestic production of nitrogen fertilizers at present, however, has not yet reached a sufficient level to meet the country's demand, and therefore the supply/demand gap is being covered by imports from foreign countries. Concerning the phosphate fertilizers, almost entire national demand is met by imported DAP, TSP and NPK, though a small amount of Thomas slag had been available as byproduct from a steel mill in the country. There is no production of potash fertilizers at this moment.

As to the availability of phosphate minerals, any deposits having possibilities for commercial development and production have not so far been discovered in the country. At this moment, therefore, the only available resource of phosphate rock can be considered one which is contained in the tails discharged from the iron ore concentration plant operated by HIPASAM in Sierra Grande. As mentioned before, main objective of this study is to investigate and seek commercial possibilities for recovering and concentrating phosphate rock from the iron ore tails available in Sierra Grande, and then is to evaluate physical and chemical characteristics of recovered phosphate rock and its suitability as raw material for the production processes of various phosphate fertilizers through laboratory tests. In line with this basic objective, the present situation of the fertilizer industry of Argentine has been investigated in order to clarify stuructural characteristics in fertilizer production, selling, distribution and consumption. At the same time, availablity of such raw materials and auxiliary materials as ammonia, nitric acid, natural gas, sulfur, sulfuric acid and serpentine, needed for the production of phosphate fertilizers has been surveyed, followed by an examination of fertilizer quality standards and regulations in the country. All of the mentioned above are thoroughly taken into consideration in the execution of the subsequent technical and financial study for the proposed phosphate fertilizer project in Argentine.

The production of fertilizer materials is being made by PETROSUR and DGFM. Both of them, however, are presupposed to supply the products to their own consumers, and it is therefore expected that there is no possibility of the supply of such materials as ammonia, nitric acid, and sulfuric acid from the existing factories to the proposed project.

Only a good quality of serpentine is available sufficiently for the project.

Fertilizer quality standards and regulations in the country has been compiled with the purpose of reflecting them to the evaluation of fertilizer products and establishment of their price levels.

On the basis of these standards and regulations, the evaluation has been made for seven different phosphate fertilizers to be studied within this study, each of which requires a different method of evaluation.

It has to be pointed out that the fertilizer industry in Argentine has the following characteristics;

i) Fertilizer prices are altered almost every month.

ii) Fertilizers are generally transacted in cash.

iii) Fertilizer distribution is compelled to be carried out in a manner highly fluctuated seasonally because the application and use of fertilizer is made concentratedly during a period from June to October.

These characteristics make it difficult for the producers to operate on a long-term production program, and impose on them an operation of seasonal fluctuation. Since the chemical fertilizer industry is one of the capital intensive industries and has to be operated on a yearly basis preferrably as steadily as possible, nevertheless, it is necessary to take proper measures so as to keep a sufficient level of products inventories by means of which the seasonal fluctuation in fertilizer consumption are absorbed. Moreover, under the circumstance as encountered in Argentine that there is always much uncertainty in the volume and price of fertilizer sales and in the exchange rate of national currency to the dollar, for example during the time at which payment for imports are made and the time at which recovery of money is made through domestic sales of fertilizers, great care is always needed for handling the fertilizer production business based on imported materials.

CHAPTER 2. FERTILIZER INDUSTRY IN THE REPUBLIC OF ARGENTINE

2-1 PETROSUR

PETROSUR is the biggest fertilizer manufacturing company in the country. It also acts as importer of fertilizer raw materials and final products, and sells all products to the national market. It has therefore a great influence on the country's fertilizer industry as a whole.

With regard to fertilizer production facilities, PETROSUR owns a natural gas-based nitrogen fertilizer complex in Campana of the Province of Buenos Aires and granular compound fertilizer factory in Bahía Blanca. In addition, it has go-downs and warehouses for bagged fertilizers in main consuming areas, and plays an important role in overall production and sales activities of fertilizers in the country.

2-1-1 Nitrogen fertilizer complex of PETROSUR in Campana

This complex of PETROSUR is located in Campana, some 75km northwest of the city of Buenos Aires, and produces ammonia, urea and ammonium sulfate starting from natural gas as principal feedstock. Although the plant site is adjacent to one of the tributary rivers of the La Plata, no facilities usable for river transportation of products are installed. Therefore, the fertilizer distribution from the factory depends totally on road transportation.

Indicated below are daily production capacities of each product in the fertilizer complex in Campana:

PRODUCT AND PRODUCTION OF RETROSUR, CAMPANA

Products	Capacity	Remarks
- Ammonia	190 TPD	- Mostly Captively consumed for Urea Production
- Prilled Urea	285	- Mostly sold as bagged in 50kg PE bag
- Ammonium Sulfate	130	- Mostly sold as bagged in 50kg PE bag
- Liquid Carbon Dioxide	60	- For soft drinks
- Electric Power	4 MW	- Captive use

Sulfuric acid needed for the production of ammonium sulfate is supplied from a sulfuric acid plant of DUPERIAL S.A. that is situated adjacent to the complex and has a daily capacity of 130 TPD operated based on imported sulfur. The fertilizer complex of PETROSUR was originally constructed by Mitsubishi Heavy Ind. in 1968. In 1982, a renovation of the urea plant was made so that the urea production capacity could increase from the original 160 TPD to 285 TPD with simultaneous reduction in ammonium sulfate production as a result of process change from the partial recycle process with crystallization to the total recycle process with direct prilling. The content of buiret in product urea is reported to be approximately 0.7% at present.

The requirements of major inputs for this complex are summarized below:

INPUTS AT PETROSUR, CAMPANA

(Unit: Daily Use)

Input	Daily Use	Remark
- Natural Gas	0.326 $MMNm^3$	Natural Gas from Campo Durán and others
- Atmospheric Air	0.180 $MMNm^3$	
- Raw Water	5,800 m^3	Well Water
- Sulfuric Acid	100 Ton	From DUPERIAL
- Electric Power Purchase	1.0 MW	

NATURAL GAS CONSUMPTION AT PETROSUR, CAMPANA

(Unit: For 1.0 Ton of Ammonia)

Item	Consumption	Remark
- Process	640 Nm^3/Ton-NH3	- Stean Reforming
- Fuel	280	- Steam Reforming
- Turbine	235	- Steam and Electric Power Generation
	1,155	

The products storage capacity of the complex is 40,000 tons in terms of bagged fertilizer products, and there are two ammonia storage tanks whose capacity is 1,600 tons and 150 tons respectively. In order to cope with the seasonal demand fluctuation, the complex has to increase the products inventories from January to May, during which a part of bagged fertilizer products is needed to be stored in the open air. A 85% of the products is shipped in bagged form and the rest in bulk, all by means of road transportation. In addition, a small amount of liquid ammonia is also distributed for the purpose of its direct application as a nitrogen fertilizer. The complex has 200 employees, requires 20 days for the scheduled annual turnaround, and is operated at a high service factor of 95% in terms of the annual stream day of 345 days.

Some portion of urea and ammonium sulfate is delivered not only to the granular compound fertilizer factory of PETROSUR located in Bahía Blanca where they are used as raw materials for the production of compound fertilizers, but also to the company's go-downs and warehouses situated in Mendoza, Salta and Bahia Blanca, etc. through which urea and ammonium sulfate are being sold to the farmers. The total production capacity of the complex is estimated at 51,100 TPY in terms of nitrogen. Judging from the situation mentioned above, however, it is concluded that the complex can not afford to supply any ammonia to the proposed phosphate fertilizer project of HIPASAM.

2-1-2 Granular compound fertilizer factory of PETROSUR in Bahía Blanca

This factory is located approximately 15 km northeast of the Port of Bahía Blanca. It has a 20.2 ha of land and consists of a granulation plant having a production capacity of 40,000 TPY and a warehouse of 20,000 tons storage capacity.

This factory in Bahia Blanca was formerly possessed by AGROMEX who had operated there a Hyperphosphate* plant since 1974 until the factory itself was transferred to PETROSUR in 1981. PETROSUR, then, installed a granular compound fertilizer plants by utilizing and relocating equipment and machneries which the company had owned in Rosario. The granulation plant is based on the solid mixing process using a pug mill and a pan granulater whose diameter is 4.3m, and is capable of producing various grades of granular compound fertilizers starting from both imported materials as DAP, TSP, MOP and SOP, and domestically available materials such as urea and ammonium sulfate.

Among principal products grades are those of (15-15-15), (12-6-12-6), (10-20-20-s), (9-15-25) and (6-21-21). Products specifications are so controled that a 80% of products falls in 2.0 to 3.5mm particle size distribution and the moisture content is in 0.5 to 1.0%. All the products are distributed to the national market after packed in 50 kg polypropylene woven bag with polyethylene inner bag.

The imported raw materials, which are mostly coming from the U.S., are unloaded in the Port of Bahia Blanca directly from a freighter to trucks, and then transported to the warehouse within the granulation factory of PETROSUR. An average size of freighters is of 5,000 tons. A 8 tons crane and 10 tons hopper is used for the unloading of fertilizer materials; the daily unloading capacity is estimated at 1,500 tons.

The transaction of granular compound fertilizers in the country is generally made in cash in acccordance with an official tariff, which is subject to frequent change (almost monthly) issued by the Secretary of Commerce. In addition, distribution/transportation cost is borne by the consumers. Consequently, the fertilizer production is compelled to be made on order bases and the distribution and sales of products has to be carried out in a way highly seasonally fluctuated. It is reported the plant operates on day time basis except for the period of peak demand during which it operates on 2-shifts basis. The factory requires 25 persons/shift. The seasonally fluctuated production of compound fertilizers in 1982 is recorded as follows;

*Granular ground phosphate rock having 29 5% of T-P_2O_5 and 10 2 of AV-P_2O_5 and particle size distribution of 90% through 300 mesh.

MONTHLY FLUCTUATION OF COMPOUND FERTILIZER PRODUCTION AT BAHIA BALANCA PLANT OF PETROSUR

January	0.64%	July	17.74%
February	0.33	August	23.39
March	8.31	September	18.56
April	0.00	October	11.37
May	2.14	November	5.31
June	11.00	December	1.11
			100.00

The aggregated production volume during the five months from June to October amounts to a 82% of the total annual production. It has to be noted that difficulties in determining the most proper time for importing raw materials and in projecting expected sales volume to the market, as well as the seasonal fluctuation of high intensity for fertilizer demand constitute structural characteristics of the fertilizer industry in the Republic of Argentine. Approximately, half of the products volume is distributed by rail and the remainder by truck, though the mode of transportation depends primarily on requests from the clients. It is reported that the production of compound fertilizers of PETROSUR in 1982 was 11,000 TPY as compared to the design capacity of the plant of 40,000 TPY, and continues being stagnant. In order to increase sales revenue of the factory, PETROSUR, in addition to the production of granular compound fertilizers, is selling imported DAP, TSP, MOP and SOP directly to the national market after bagging them in this factory.

At present, PETROSUR is importing approximately 30,000 TPY of DAP, and in view of foreign currency expenditure and ensuring stable supply at reasonable price, therefore, it wishes to purchase DAP or MAP from would-be domestic producers, so far as they can be manufactured within the country. On the basis of experience obtained through the production and marketing of Hyperphosphate, PETROSUR realizes that phosphate fertilizers with high water soluble phosphate should be adequate for the country's agriculture and that the market of those having less water sulubility is restricted and found only in the area of grass.

2-2 DGFM

DGFM is the largest and governmental mining and mineral processing enterprise in the Republic of Argentine.

In regard to fertilizer related plants, it has a small ammonia plant in Córdoba and two small sulfuric acid plants in Córdoba and Berisso, both of which are based on imported sulfur. It also produced Thomas slag as byproduct from the steel mill in Jujuy. None of these plants, however, can afford to supply their products to the proposed phosphate fertilizer project.

2-2-1 Ammonia plant in Córdoba

DGFM possesses and operates a 40 TPD ammonia plant, a 130 TPD nitric acid plant and a 25 TPD industrial grade ammonium nitrate plant in Río Tercero, Córdoba. Almost all ammonia produced is captively used for the production of nitric acid and ammonium nitrate. About 1,000 tons of liquid ammonia is sold for industrial purposes.

This ammonia plant was originally installed based on Casale process utilizing charcoal as feedstock, which was later substituted for natural gas in 1981. Also in 1981, a nitric acid plant based on Pintsch Bamag process was constructed by Espindesa, Spain. The majority of nitric acid is sold, in 98% concentration, to Petroquímica Río Tercero S.A., where it is used for the production of tolylene diisocyanate(TDI)*. Incidentally, ammonium nitrate product is based on crystallization method, and there is no production of prilled ammonium nitrate.

2-2-2 Thomas slag

DGFM owns a steel mill in Jujuy based on revolving furnace using charcoal as fuel and having a capacity of 300,000 TPY in terms of blister steel. Thomas slag byproduced from this plant has been sold as phosphate fertilizer. However, its production has recently been almost stopped. It is reported the production in 1972 reached 10,000tons. A typical analysis of Thomas slag of DGFM is as follow;

STANDARD SPECIFICATION OF THOMAS SLAG FERTILIZER

(Wt %, Dry Basis)

Total P_2O_5	18 (17-19)%	SiO_2	8%
Citric Acid Soluble P_2O_5	15 (14-16)	MnO	5
CaO	47 (45-50)	MgO	3
Fe_2O_3	17	Al_2O_3	2

2-2-3 Sulfuric acid plants of DGFM.

DGFM owns two small sulfuric acid plants in Berisso and Río Tercero, whose capacity is reported to be 33,000 TPY and 36,000 TPY, respectively. Both of the plants are not in a position to be able to supply sulfuric acid to the phosphate fertilizer project.

*The plant capacity of TDI is 16,000 TPY.

2-2-4 Ammonium sulfate plant of SOMISA.

The SOMISA has a 20 TPD of ammonium sulfate plant in San Nicolás, which is based on ammonia recovered from coke oven gas. The plant was completed in 1951, and the product has been sold for both fertilizer and industrial uses.

2-3 Phosphoric Acid Plant of SUDANFOS.

SUDANFOS has a factory in Buenos Aires that manufactures industrial grade phosphoric acid and phosphates starting from imported elemental phosphorus. Elemental phosphorus, which is mainly imported from Canada in 200 liter drum (340kg lot), is converted to phosphoric acid by air oxidation. Phosphoric acid is, then, neutralized with various alkaline bases, and the neutralization products are dryed in a rotary dryer or spray dryer to produce various phosphates. It is reported that the capacity of the factory is 10,000 TPY in terms of elemental phosphorus (22,914 TPY in terms of P_2O_5), and however, that the actual operation in 1983 is of 3,500 TPY in terms of elemental phosphorus (8,020 TPY in terms of P_2O_5).

The company has no plan to produce elemental phosphorus itself based on either imported phosphate rock or domestically recovered phosphate rock by HIPASAM, however it is interested in producing industrial grade phosphoric acid by the purification of wet-process acid by solvent extraction process, if wet-process acid is domestically produced in the future.

It is noted that SUDANFOS is an affiliated company of Hoechst A.G., West Germany that has a purificiation technology of wet-process phosphoric acid by solvent extraction process. At present, there are several commercial plants in West Germany and Japan manufacturing purified phosphoric acid staring from wet-process acid using solvent extraction technology.

Therefore, also in Argentine, there will be certain possibility for the realization of the above mentioned scheme.

At present, the factory has 150 employees, and also produces industrial grade calcium carbonate in addition to various phosphates. Rapid increase of the demand for industrial grade phosphates is not expected. Among principal products of the factory are sodium tripolyphosphate, sodium pyrophosphate, disodium phosphate, soium metaphosphate, monocalcium phosphate, dicalcium phosphate and phosphoric acid. This factory originally started with the production of phosphoric acid based on catlle bone as main raw material, which was then replaced by imported elemental phosphorus.

2-4 Hyperphosphate Plant of AGROMAX (in Uruguay)

AGROMAX has a fertilizer factory in Montevideo, Uruguay, from which a part of the product is exported to Argentine. The following summarizes an outline of this factory. It manufactured approximately 50,000 TPY of Hyperphosphate and granular compound fertilizers in 1982, out of which 5,000 TPY was exported to Argentine.

Hyperphosphate is mainly composed of finely ground (80% through 270 mesh) carbonate originated phosphate rock found in Tunisia, North Carolina of the U.S., and Israel, and is used either as it is or after granulated with the addition of about 5% of MOP or ammonium sulfate as granulation agent. The general specification of Hyperphosphate is as follow;

- Total P_2O_5	30%
- Citric Acid Soluble P_2O_5	12
- Formic Acid Soluble P_2O_5	21
- Available P_2O_5	5
- Water Soluble P_2O_5	0

The factory consists mainly of a 20 TPH Hyperphosphate plant (grinding), a 20 TPH mixing plant, and a 15 TPD granular compound fertilizer plant (based on pan-pug mill granulation). The total employee is 70 persons. Principal grades of products are as follows;

- [0-29	(C - P_2O_5 12)- 0]	:	Granular	Hyperphosphate
- [0-30.5	(C - P_2O_5 12)- 0]	:	Powder	Hyperphosphate
- [0-40	(C - P_2O_5 31)- 0]	:	TSP +	Hyperphosphate
- [0-44	(C - P_2O_5 42)- 0]	:	TSP +	Hyperphosphate
- [15-16	(Av- P_2O_5 15)-15]	:	NPK	
- [13-46	(Av- P_2O_5)-0]	:	NPK	
- [7-41	(Av- P_2O_5)-0]	:	NPK	

The guarantee of nutrients content is made in terms of total P_2O_5 and citric acid soluble P_2O_5 for Hyperphosphate, and in terms of available P_2O_5 for DAP based NP/NPK granular compound fertilizers. The utilities requirements in this factory are estimated as follows:

UTILITY CONSUMPTION AT AGROMAX, URUGUAY

(Unit: per 1.0 Ton of Product)

	Granular Hyperphosphate	Granular NP/NPK
- Electric Power, kWh	40	15
- Fuel Oil, Liter	16	10
- Raw Water, m^3	0.12	0.05
- Steam, Ton	0.01	0 01

It has to be noted that the analysis of Hyperphosphate is referred to C-P_2O_5(more than 55%) in Uruguay, F-P_2O_5(more than 55%) in EC countries except West Germany, and F-P_2O_5(more than 60%) in Germany and Argentine. The fertilizer efficiency of Hyperphosphate is closely related to the acidity of soil. It is considered that in case of the soil whose acidity is of pH 6, it has identical efficiency to that of SSP, on the basis of total P_2O_5, and for the soil whose pH ranges from 6.5 to 7.0, it becomes identical fertilizer efficiency to SSP based on the weight of fertilizers. Hyperphosphate is generally sold at a same price as SSP on weight basis.

AGROMAX recorded a sales volume of 120,000 TPY in 1974, which has recently decreased to a level of 50,000 TPY, because of reduced demand for Hyperphosphate. All the products are shipped to the market in a 50kg PE bag, and the exports to Argentine are made always by truck up to the final destinations without doing any transshipment.

CHAPTER 3. FERTILIZER RAW MATERIALS

3-1 Natural Gas

The total reserves of natural gas (as of Jan. 1, 1983) in the Republic of Argentine is estimated at 25.2 TCF. The country's major gas deposits are situated in Jujuy, Salta, Mendoza, Neuquén, Santa Cruz, RíoNegro and Tierra del Fuego. Recent exploration activities have confirmed additional gas reserves so that an unofficial estimate could reach more than 40.0 TCF of gas reserves.

In regard to the production of natural gas in the country, the annual aggregated volume of production is reported to be 0.5496 TCF in 1983. The development and exploitation of natural gas is being principally made by YPF, and the pipeline transportation and distribution of natural gas thus produced is carried out by Gas del Estado. The country's natural gas pipeline route and the analysis of natural gas are shown in Figure III-1 and Table III-1 respectively.

Apparently, the Republic of Argentine is abundant in natural gas resources, and is also in an advanced stage of its development. Based on the high quality natural gas resources available in the country, nitrogen fertilizers and some petrochemicals are already produced. As future utilization plans for natural gas, a variety of projects for the production of nitrogen fertilizers, methanol, petrochemicals, and LNG (646 MMSCF capacity in Puerto Madrin) are considered. Production of sponge iron is planned, too.

It can be concluded in view of quality and quantity that there is no problem as to the availability of natural gas needed for the proposed phosphate fertilizer project both as raw material and as fuel.

As can be seen in Figure III-1, each one of the three candidate site locations for the proposed phosphate fertilizer project, which are Sierra Grande (PS-1), San Antonio Oeste (PS-2) and Bahia Blanca (PS-3), has direct access to the existing 30 inches high pressure gas pipeline operated by Gas del Estado and therefore can be provided easily with natural gas.

According to Gas del Estado, the natural gas price is classified into two levels that are for fuel and chemical industry purposes and the relative price both for fuel and chemical industry ranges from 1.00 to 0.45 depending upon the consuming area that are divided into nine zones of the country.

3-2 Ammonia and Nitric Acid

Ammonia and nitric acid are basic raw materials for the production of ammonium phosphates (Monoammonium Phosphate; MAP and Diammonium Phosphate; DAP) and Nitric Phosphates (NP) among various phosphate fertilizers under consideration within the proposed study. Nitric acid is also derived from ammonia that is generally produced based on natural gas. For this reason, the availability of ammonia and nitric acid is surveyed.

An outline of ammonia and nitric acid plants in the country is already presented in relation to the explanations made on PETROSUR and DGFM in the previous chapter. Table III-2 summarizes the country's ammonia and its derivatives plants. The total production capacity of ammonia and nitric acid is estimated at 240 TPD (71,280 TPY) and 130 TPD (38,610 TPY) respectively.

These products have their own captive users and therefore can not be considered available for the proposed phosphate fertilizer project as its raw materials sources.

It is therefore necessary that the proposed project be studied either based on imported ammonia or on the condition that a new ammonia plant is included within the scope of the proposed phosphate fertilizer project.

The ammonia requirement for this project ranges from 9,300 to 90,000 TPY depending on the type of phosphate fertilizers selected.

Regarding new nitrogen fertilizer projects in the country, the project of INPAGRO SAICF has already been approved under a governmental Decree No.22333 and therefore is considered the most advanced at this moment. However, there is no concrete program yet announced for the construction of the plant

Recently, plans for a small nitrogen fertilizer plant are also promoted both in Neuquén and Salta, however, they are not yet in the implementation stage of the plant.

3-3 Sulfuric Acid and Sulfur

There are some sulfur (Brimstone) reserves in Salta, and several other places, from which about 20,000 TPY of sulfur were, reportedly, produced in the past. The production capability has, however, decreased sharply at present. The production of sulfuric acid depends mostly on imported sulfur, and there is no potential suppliability of sulfur from domestic sources expected for the proposed phosphate fertilizer project.

According to Table III-3 and statistic data presented below which summarize information related to sulfuric acid in the country, the total production capacity of sulfuric acid plant in 1982 is estimated at 392,600 TPY and the production at 280,000 TPY, and therefore the rate of capacity utilization in 1982 is estimated at 71.4%. Some of the sulfuric acid plants in Argentine are based on tail gas from the nonferrous metal smelters, but most of the plants produce sulfuric acid from imported sulfur.

There are nine sulfuric acid plants at this moment in the country. The production is balanced with the domestic consumption without significant volume of imports and exports. Although certain new projects for sulfuric acid production are reported, they are hardly considered at this moment as possible supply sources of sulfuric acid for the proposed fertilizer projects.

This project, therefore, needs to be studied on the condition that a new sulfuric acid plant be installed as a part of the project itself. Incidentally, the sulfuric acid requirement for the project is ranging from 58,500 TPY to 80,200 TPY depending upon the type of phosphate fertilizers finally produced. Presented below are statistical data on sulfuric acid in Argentine;

SURFURIC ACID IN ARGENTINE

(Unit: 98% H_2SO_4, TPY)

Year	Production	Import	Export
1977	244,000	400	100
78	244,800	1,400	100
79	278,000	400	700
1980	241,000	2,400	600
81	225,600	-	-
82	280,000	-	500

As indicated in Table III-4, sulfur is imported from Canada, the U.S.A. and Mexico. Historically the price of sulfur fluctuated a lot, and recorded US$97 to 125 C&F in 1983.

3-4 Phosphate Rock and Potassium Salts

At present, there is no phosphate deposit which has possibility of commercial production in the Republic of Argentine, though it is reported that some deposits exist in Jujuy, Neuquén, Mendoza and San Juan without detailed investigation on their quality and size of reserves.

The only possibility is the recovery of phosphate rock (apatite concentrate) contained in the tails discharged in Sierra Grande, Río Negro as waste from the iron ore concentration plant operated by HIPASAM. This tails contain usually 7.08% of $P_2O_5$and, 27.53% of Fe, and its volume is expected to reach a level of one million tons annually in the near future. The recovery of phosphate rock mentioned here consitutes an important part of the proposed project and is a major subject of research and investigation within the framework of this study, whose results are mostly reported in the following Chapter IV titled "Phosphate Rock Concentration and Supply" .

As to potassium salts, there is no deposit with commercial possibility of development in the country.

3-5 *Serpentine*

Surpentine is a magnesium silicate mineral having general chemical formula of (Mg, $Fe)_3SiO_2(OH)_4$, and is utilized as raw material for the production of fused magnesium phosphate (FMP), which is one of the phosphate fertilizers to be considered in this study.

For this reason, the availability of serpentine has been surveyed as to its reserves, production, quality and price in the country.

It has to be noted that fused magnesium phosphate has advantageous characteristics that it can be manufactured even from low grade phosphate rock with high contents of such impurities as ferric oxide, alumina and magnesia, and that it does not require expensive raw materials as sulfur, sulfuric acid and nitric acid as in the case of other phosphate fertilizer.

There are some deposits of serpentine in Córdoba and Mendoza, whose size of reserve is roughly estimated at more than 3 million tons, though there is nothing about accurate estimate The actual production in 1980 is reported to be 30,000 tons from Córdoba and 1,000 tons from Mendoza. It is mostly utilized as construction material and is used, in a very minor quantity, by HIPASAM as granulation and sintering agent of iron ore.

The production and sales of serpentine in Córdoba is being carried out in the areas of Alta Gracia, Santa Rosa de Calamuchita and Río de Los Sauces, by the mining companies as Molinos Tarquini SAIC and Maquimas Minas Minerales SAIC. They are in a position to be able to increase the production The requirement of serpentine for the production of fused magnesium phosphate in this study is estimated at 86,000 tons annually.

The analysis of serpentine available in the country is shown below as compared to a standard analysis of serpentine used in Japan as raw material for the production of fused phosphate.

SPECIFICATION OF SURPENTINE

Item, %	Alta Gracia, Córdoba, Argentine	Río de Los Sauces, Córdoba, Argentine	Japan
SiO_2	36-40	36.7	38.0
MgO	34-38	37.4	38.5
CaO	-	4.5	2.3
Al_2O_3	1.9-2.0	1.0	5.0
Fe_2O_3	-	7.7	4.0
Ignition Loss	15-17	16.3	9.5
Bulk Density	1.5	1.5	1.5

Table III-5 indicates the typical analysis of serpentine purchased by HIPASAM and used in its pelletizing plant of iron ore located in Punta Colorada, with supplemental information on other auxiliary materials.

The price of serpentine is estimated at US$ 7.9/ton at the mining site of Córdoba in 1983, and the transportation cost by truck from Córdoba to Punta Colorada, Río Negro (approx. 1,550km) is estimated at US$ 22.57/ton.

It is concluded that serpentine can be supplied domestically, without any problem of its quality and quantity, to the proposed phosphate fertilizer project in the Republic of Argentine

CHAPTER 4. FERTILIZER QUALITY STANDARDS AND REGULATIONS IN THE REPUBLIC OF ARGENTINE

4-1 Quality Standards and Regulations of Fertilizers

The quality standards of fertilizers and their testing methods in Argentine are specified in regulations issued by IRAM (Instituto Argentino de Racionalización de Materiales).

IRAM regulates the classification, minimum requirements for fertilizer nutrients and physical properties, and maximum allowances for water, free acid and biuret contents, through which the production, importation and sales of fertilizers in the Republic Argentine are controled.

Table III-6 shows a summary of fertilizer quality standards and regulations in the country. It has to be noted that the method of analysis and minimum standards are defined each by each depending on the type of fertilizer.

The following five methods are specified by IRAM for evaluating phosphate fertilizers, and one or two of them are applied depending on the type of phosphate fertilizer;

- Total P_2O_5:	$T\text{-}P_2O_5$
- Available P_2O_5 (Asimilable, Water Soluble plus Neutral Ammonium Citrate Soluble).	$Av\text{-}P_2O_5$
- Formic Acid Soluble P_2O_5:	$F\text{-}P_2O_5$
- Citric Acid Soluble P_2O_5:	$C\text{-}P_2O_5$
- Water Soluble P_2O_5:	$W\text{-}P_2O_5$

This problem of the evaluation methods will be discussed more in detail in Part V in connection with results of the laboratory work on the manufacture of various phosphate fertilizers based on the phosphate rock actually recovered from the iron ore tails in Sierra Grande.

It is incidentally noted that the fertilizer nitrogen component is referred to total nitrogen (T-N), and the potash component is referred to water soluble potassium salts expressed in $W\text{-}K_2O$. According to IRAM, the analysis of fertilizer nutrients is expressed, in principle, in terms of weight percentage of each nutrient element (N,P,K).

In this study, however, the fertilizer analysis expressed in terms of the weight percentage of oxides (N, P_2O_5, K_2O) is adopted, since this system is also internationally commonly used. Conversion factors between the two system are presented in the introductory part of the report.

Table III-1 NATURAL GAS SPECIFICATION IN ARGENTINE

	Location				
	San Sebastian	Canadon Piedras	Canadon Alfa	Condor Oeste	Condor
Analysis, Molar Percent					
N_2	2.26	1.32	1.48	1.85	1.08
CO_2	0.01	0.04	0.02	0.07	0.24
CH_4	94.35	89.53	89.00	90.54	91.06
C_2H_6	2.96	5.05	5.22	4.12	5.14
C_3H_8	0.40	2.31	2.48	1.88	1.35
Iso-C_4H_{10}	0.01	0.63	0.67	0.36	0.26
Normal-C_4H_{10}	0.01	0.72	0.78	0.48	0.36
Iso-C_5H_2	-	0.19	0.16	0.17	0.12
Normal-C_5H_{12}	-	0.12	0.13	0.12	0.10
C_6H_{14}	-	0.06	0.04	0.24	0.17
C_7H_{16} and Higher	-	0.03	0.02	0.17	0.12
High Heating Value,					
Cal/m^3	9075	9944	9970	9780	9725
MJ/m^3	37.98	41.62	41.72	40.93	40.70
Low Heating Value,					
Cal/m^3	8179	8987	9012	8836	8783
MJ/m^3	34.23	37.61	37.72	36.98	36.76
Specific Gravity (Air=1)	0.583	0.636	0.639	0.631	0.621
Specific Heat at Constant,					
Pressure, Cal/m^3°C	0.362	0.384	0.385	0.381	0.378
Volume, Cal/m^3°C	0.278	0.300	0.301	0.297	0.294
Constant, K=Cp/Cv	1.301	1.279	1.278	1.283	1.285
Combustion Air, m3/m3	9.58	10.50	10.52	10.33	10.27
Flue Gas,					
Dry, m3/m3	8.61	9.44	9.47	9.29	9.23
Wet, m3/m3	10.60	11.57	11.60	11.39	11.33
Explosive Limit,					
Low, % gas/air	4.98	4.59	4.58	4.66	4.67
High, % gas/air	15.24	14.68	14.68	14.83	14.82
Compressibility, 15°C, 1.0 ata	0.9980	0.9975	0.9974	0.9976	0.9976
Supplier	Gas del Estado				

Notes: 1) The data is compiled at Gas del Estado, Argentine in 1982.

Table III-2 AMMONIA AND ITS DERIVATIVES PLANTS IN ARGENTINE

Firms	Location	Products	Capacity TPD	Raw Material
EXISTING PLANT				
Petrosur SAIC	Campana, Buenos Aires	Ammonia	190.0	Natural Gas
		Urea	285.0	
		Ammonium Sulfate	130.0	
		Nitrogen Equivalent	156.2	
Petrosur SAIC	Bahía Blanca Buenos Aires	Granular Compound Fertilizer	133.0	Urea, AS, DAP
		Nitrogen Equivalent	0.0	
Direccion General de Fabricaciones Militares	Río Tèrcero, Córdoba	Ammonia	40.0	Natural Gas
		Nitric Acid	130.0	
		Ammonium Nitrate	25.0	
		Nitrogen Equivalent	32.8	
Sociedad Mixta Siderúgica	San Nicolás, Buenos Aires	Ammonium Sulfate	20.0	Coke Oven Gas
		Nitrogen Equivalent	4.2	
Electrochlor SAIC	Capitán Bermúdez Santa Fé	Ammonia	10.0	Electrolysis of Sodium Chloride Solution
		Nitrogen Equivalent	8.2	
	Nitrogen Equivalent Sub-Total		201.4	
STUDY STAGE PROJECT				
INPAGRO SAICF	Rosario, Buenos Aires	Ammonia	1,000.0	Natural Gas, (Decreto No. 2,2333 December 18, 1981)
		Urea	1,435.0	
		Nitric Acid	229.0	
		Ammonium Nitrate	295.0	
		Nitrogen Equivalent	822.0	
Fertilizates Neuquinos SA	Praza Huincul, Neuquén	Ammonia	175.0	Natural Gas
		Urea	300.0	
		Nitrogen Equivalent	143.0	
Salta Province	Salta, Salta	Ammonia	200.0	Natural Gas
		Urea	345.0	
		Nitrogen Equivalent	164.4	
Pérez Companc	Punta Loyola, Santa Cruz	Ammonia	1,350.0	Natural Gas
		Urea	1,750.0	
		Nitrogen Equivalent	1,110.0	
Magallanes	Tierra del Fuego	Ammonia	1,500.0	Natural Gas
		Urea	1,900.0	
		Nitrogen Equivalent	1,220.0	

Table III-3 LIST OF SULFURIC ACID PLANTS IN ARGENTINE

(Unit: 100 % H_2SO_4, TPY)

	Organization	Location	Capacity	Raw Material
(1)	Existing Facilities			
	- Compania Química SA	Buenos Aires	70,000	Imported Sulfur
	- Cooperativa de Trabajo Zarate LTDA	Buenos Aires	18,000	Zinc Smelting
	- Duperial SA	San Lorenzo	80,650	Imported Sulfur
	- Duperial SA	Campana	43,550	Imported Sulfur
	- Dirección General de Fabricaciones Miltares	Berisso	33,000	Imported Sulfur
	- Dirección General de Fabricaciones Miltares	Río Terceró	36,000	Imported Sulfur
	- Comisión Nacional de Energía Atómica	Malangue	8,800	Imported Sulfur
	- Obras Sanitarias de la Nación	Buenos Aires	30,600	-
	- Sulfacid SAIFC	San Lorenzo	72,000	Zinc Smelting
	Sub-total		392,600	
(2)	Study Stage Projects			
	- Bajo de la Alumbrera	Catamarca	350,000	
	- El Pachón	San Juan	350,000	
	Sub-total		700,000	

Table III-4 SULFURIC ACID IN ARGENTINE

(Unit: TPY)

	1981	1982	1983
(1) Production and Raw Material from			
Brimstone		191,000	
Pyrite	-	-	-
SOF		49,000	
	228,000	240,000	
(2) Consumption and Uses for			
Fertilizer		30,000	
Non-Fertilizer		210,000	
	228,000	240,000	
(3) Import of Brimstone from			
Canada		91,600	
USA		7,600	
Mexico		37,700	
	85,000	136,900	
(4) Brimstone Price, US$/Ton			
FOB Price			
Canada, Vancouver	105/120	110/113	83/100
Poland, Gdansk	120/140	115/140	100/115
USA, US Gulf	120/135	110/135	85/110
Middle East, Gulf	140/150	112/130	93/108
C&F Price, Solid			
Europe	140/150	118/135	97/120
Asia	125/180	125/160	110/125
South America	140/175	118/160	97/125

Sources: "Sulphur" by British Sulphur Corp., Ltd. and IFA

Table III-5 SPECIFICATION OF IRON ORE CONCENTRATE OF HIPASAM AND OTHER CHEMICALS USED AT HIPASAM, ARGENTINE

(Unit: Wt%, Dry Basis)

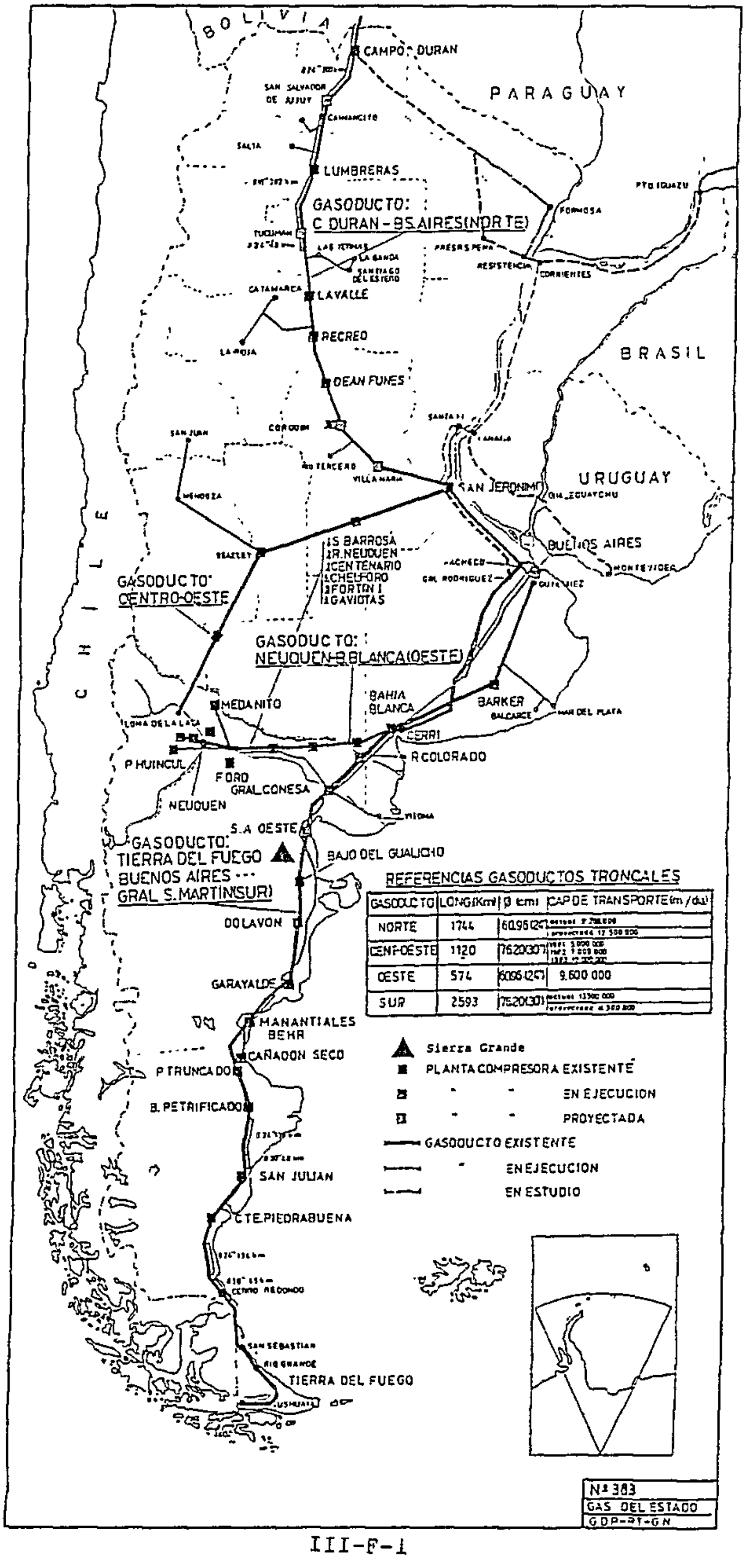
Analysis	Iron Ore Concentrate of HIPASAM	Bentonite	Limestone	Serpentine	Dolomite	Silica Sand
Fe (Total)	68.50	3.10	1.0	5.10	0.70	0.50
Fe (II)	22.20	-	-	-	-	-
P	0.14	0.01	0.03	0.05	-	0.02
SiO_2	1.60	61.80	12.00	38.50	8.70	96.00
Al_2O_3	1.70	19.80	4.00	1.40	0.30	0.40
CaO	0.40	1.20	63.00	2.20	31.50	0.24
MgO	0.10	3.20	3.00	35.60	16.00	0.06
S	0.06	0.39	0.09	0.03	-	0.03
Na_2O	0.02	1.90	0.05	0.11	<0.01	-
K_2O	0.03	0.26	0.30	0.04	<0.01	-
TiO_2	0.11	0.19	0.06	-	0.01	-
V_2O_5	0.20	0.02	-	-	-	-
MnO	0.04	0.02	-	-	0.06	-
Ingnition Loss	0.70	5.4	15.80	14.10	42.70	1.00

Table III-6 FERTILIZER QUALITY STANDARD AND CONTROL ORDER IN ARGENTINE

Code Norma IRAM	Publication Date	Code Title	Contents	Fertilizer Quality Standard: Fertilizer	Type	Grade, %: N	P_2O_5	K_2O	Analysis Method	Moisture, wt%	Size, mm
22-401	May 22, 1962	Definition	Definition of Terms and 53 Kinds of Fertilizer with Minimum Nutriente	Escorias Thomas	-	0.0 -	11.9 -	0.0	C - P_2O_5	-	-
				Amonia		82.0 -	0.0 -	0.0	T - N		
				MAP		11.0 -	48.0 -	0.0	Av - P_2O_5		
				DAP		21.0 -	53.0 -	0.0	Av - P_2O_5		
				Guano		5.0 -	9.8 -	0.0	Av - P_2O_5		
				AN		33.5 -	0.0 -	0.0	T - N		
				CAN		20.5 -	0.0 -	0.0	T - N		
				NP		20.0 -	19.0 -	0.0	Av - P_2O_5		
				NP		28.0 -	14.2 -	0.0	Av - P_2O_5		
				AS		20.5 -	0.0 -	0.0	T - N		
				SSP		0.0 -	17.8 -	0.0	Av - P_2O_5		
				TSP		0.0 -	39.8 -	0.0	Av - P_2O_5		
				Urea		45.0 -	0.0 -	0.0	T - N		
				MOP		0.0 -	0.0 -	57.8	W - K_2O		
				SOP		0.0 -	0.0 -	48.0	W - K_2O		
22-402	June, 1964	Sample Preparation	Sample and Preparation		-	-	-	-	-	-	-
22-407	July 1963	Determination of P_2O_5	Method of Analysis - Total P_2O_5 - Water Soluble P_2O_5 - Ammonium Citrate Soluble P_2O_5 - Available P_2O_5 (Asimilable)		-	-	-	-	-	-	-
22-407 (II)	June, 1, 1979	Determination of Water Sollubie P_2O_5	A 5 gr Sample in 450 ml Water at 20°C, 35 RPM for 0.5 hours		-	-	-	-	-	-	-
22-407 (III)	Junly 1, 1978	Determination of Ammonium Citrate Soluble P_2O_5	Residue of 22-407 (II) in 100 ml at 65°C, 35 RPM for 1.0 hours		-	-	-	-	-	-	-
22-407 (IV)	July 16, 1979	Determination of P_2O_5	Vanadomolybdate Gravimetric		-	-	-	-	-	-	-
22-407 (V)	August, 1978	Determination of P_2O_5	Vanadomolybdate Gravimetric		-	-	-	-	-	-	-
22-407 (VI)	June 18, 1979		Vanadomolybdate Gravimetric		-	-	-	-	-	-	-
22-419	September, 1979	SSP	Product Quality	SSP	I (Powder)	0.0 -	18.5 - (17.0)	0.0	Av, W - P_2O_5	8	(-) 4.5, (+) 1.4mm, 80%
				SSP	II (Granular)	0.0 -	19.5 - (18.0)	0.0	Av, W - P_2O_5	4	(+) 6.3mm, 0%
22-420	June, 1965	Guano	Product Quality	-	-	5.0 -	6.0 -	0.0	T - N, Av - P_2O_5	10	-
22-421	June, 1965	Ammoniated Superphosphate	Product Quality	Amm SSP	I	4.0 -	12.6 -	0.0	T - N, Av - P_2O_5	10	-
				Amm TSP	II	4.0 -	37.8 -	0.0	T - N, Av - P_2O_5	12	-
22-425	September, 1979	Urea	Product Quality	Urea	A	46.0 - (1)	0.0 -	0.0	T - N, Biuret	0.5	-
				Urea	B	45.0 - (1)	0.0 -	0.0	T - N, Biuret	0.5	-
22-441	November, 1979	Natural Phosphate	Product Quality For Direct Application	Phosphate	A (Powder)	0.0 -	26.0 - (15.6)	0.0	T, F - P_2O_5	8	(-) 0.63mm, 90%
				Phosphate	B (Granular)	0.0 -	24.0 - (14.4)	0.0	T, F - P_2O_5	4	(-) 0.163mm, (+) 0.663mm, 20%
22-442	May, 1977	Determination of Formic Acid Soluble P_2O_5	A 1.0 gr Sample in 100 ml Formic Acid (2.0% HCOOH), at 20°C, 35 RPM for 2.0 hours	-	-		-		F - P_2O_5	-	-
22-446	February 2, 1979	Determination of Citric Acid Soluble P_2O_5	A 5.0 gr Sample in 450 ml Citric Acid (2.0%), at 20°C, 35 RPM for 0.5 hours	-	-		-		C - P_2O_5	-	-
22-450	November, 1979	TSP	Product Quality	TSP	I (Powder)	0.0 -	44.0 - (39.0)	0.0	T, W - P_2O_5	6	-
				TSP	II (Granular)	0.0 -	45.0 - (40.0)	0.0	T, W - P_2O_5	4	(-) 4.5mm, (+) 1.5mm, 80%

Notes: 1) IRAM: Instituto Argentino de Racionalización de Materiales, Chile 1192, Buenos Aires, Argentine
2) Fertilizer nutrients are expressed in terms of elements (N, P and K) Primarily, but oxides (N, P_2O_5 and K_2O) forms are also allowed as alternative. In commercial fields, N, P_2O_5 and K_2O expressions are widely accepted.)
3) Av = Available (Asimilable), T = Total, C = Citric Acid Soluble, F = Formic Acid Soluble, W = Water Soluble. K_2O is always expressed in water soluble form.

Figure III-1 NATURAL GAS PIPELINES IN ARGENTINE



PART IV

PHOSPHATE ROCK CONCENTRATION AND SUPPLY

PART IV

PHOSPHATE ROCK CONCENTRATION AND SUPPLY

CHAPTER 1. PREFACE

In Argentine the phosphate rock deposits were identified in Jujuy, Neuquén, Mendoza and San Juan by 1982, however so far no detailed survey and study were undertaken on the quality and quantity of such phosphate rock reserves, and it is considered that there is no phosphate rock reserve for suitable of commercial mining in Argentine at present.

Only one possibility is the phosphate minerals in the tails of the iron concentration plant of HIPASAM, Sierra Grande, Río Negro. Therefore, the present conditions of the iron ore mining, concentration and pelletizing operations at HIPASAM and the possibility of the concentration of phosphate rock concentration, only the non-magnetic tails is considered suitable.

The mining capacity of raw iron ore at HIPASAM is 3,500,000 TPY and the production capacity of iron ore concentrate pellet is 2,000,000 TPY. The annual tonnage of tails is 1,000,000 TPY in a near future and its analysis is 7.08% of P_2O_5 and 27.53% of Fe. As for the raw materials of the phosphate rock concentration, only the non-magnetic tails is considered suitable.

The P_2O_5 reserves in the non-magnetic tails is calculated as 65,250 TPY-P_2O_5 and the test results of concentration processes show that the phosphate rock will be produced at P_2O_5 recovery of 55.5%. Therefore it is possible, to recover 35,650 TPY-P_2O_5 from the non-magnetic tails of HIPASAM if a phosphate rock concentration plant in built.

The mechanism of iron ore formation at Sierra Grande is considered that at first iron minerals were deposited at the bottom of a lake by erosion and transportation. The iron minerals formation was then received thermo-dynamic metamorphism by intrusion of igneous rock and at a same time, forming an anticlinal structure which were fractured by tension. Further by the dislocation of sedimentary structure, the western part of ore body was eroded and fractionated by the post-tectonic movements. The extrusion of ingeous rock were observed once again to form the iron ore body at present.

The major igneous rock is quartz porphyry or rhyolite. The first iron mineral deposit at the lake is considered limonite which was converted into hematite and then further converted into magnetite by thermal metamorphism. The crystallization of magnetite was accelerated by the second intrusion of igneous rock.

The major minerals of iron ore of Sierra Grande are magnetite, martite, hematite and the associated minerals are chlorite and apatites, and also a small amounts of lazulite and andalusite are identified.

The iron ore reserves in Sierra Grande is, as shown in Table IV-1, approximately 500 million tons and the reserves of the south mine is 231 million tons which at presently are mined and will have more than fifty years minable reserves.

The cut-off grade is 30% as magnetic iron and 41.42% as magnetite. The average grade of deposit body is 54.80% of Fe, 3.28% of P_2O_5 as are shown in Table IV-1. The upper deposit is martite majority (martite + 5% magnetite) and the lower deposit is magnetite majority (70% magnetite + martite).

The iron ore in Sierra Grande has high phosphate concentration and is not suitable for direct application for steel making, therefore the raw iron ore is ground and concentrated by magnetic separation and flotation process to make concentrated iron ore pellets as well as a high phosphate tails which are discarded in a pond at present

The major objectives of the study is to seek the possibility to concentrate and recover the phosphate rock from the tails which will be used as intermediate for the production of phosphate fertilizer in Argentine.

As the P_2O_5 concentration in the raw ore is 3.28%, therefore total P_2O_5 in the iron ore reserves in the south mine is 6 98 million ton of P_2O_5. The iron ore is concentrated upto 68.4% of Fe and 0.14% of P_2O_5 at the iron ore concentration plant and the non-magnetic tails is discharged with quality of 27.53% of Fe and 7.08% of P_2O_5.

CHAPTER 2. IRON ORE MINING AND CONCENTRATION

2-1 Mining

The south mine of Sierra Grande has a dip of 55 to 60° with ore layer thickness of 10 to 14 meter and the sub-level mining method is applied with level span of 70 meter and sub-level span of 23 meter.

Fan drilling is applied to drill ores and at a blasting by ANFO explosives, approximately a 350 ton of ores are obtained. The charging of explosives of 150 to 180 gr per ton of ore are blasted. There are eight stopes installted and four of them are at present operating.

The blasting ores are dropped into the chute and stored in the ore bin at the lowest level. The run-of-mine ores are primarily crushed by the jaw crusher and lifted up by the skip. The capacity of crusher and skip are 800 TPH and 700 TPH, respectively.

2-2 Preconcentration

The mined ore in the stock yard are sent by conveyor to the preconcentration plant, where the ores are treated at the two-stage dry magnetic separators (magnetic flux of 600 gauss) and non-magnetics are separated and discarded. The magnetics are crushed and screened at the vibrating screen with 25 mm opening mesh, and the over sized ores are fed to the pebble mill and the under sized ores are fed to the rod mill for further grinding.

2-3 Iron Ore Concentration

There are three identical trains of grinding and flotation in the iron ore concentration plant. However, the thickner is single trained for processing of ores. The iron ore concentration plant is located in Sierra Grande, Rio Negro and the concentrated iron ore is sent in the pipeline as slurry to Punta Colorada where the iron ore pellets are produced for steel making. The iron ore concentration plant has following five sections;

- Primary Grinding/Primary Magnetic Separation
- Secondary Grinding/Classification/Secondary Magnetic Separation
- Iron Ores Concentration by Reverse Flotation
- Scavenging of Tails
- Thickening of Iron Ores and Tails

2-3-1 Primary grinding/primary magnetic separation

The iron ores from the preconcentration plant is further ground for removing gangue ores. The iron ore is treated in the rod mill (3.9 mD × 5.3 mL × 1,000 kWh) where iron ores are ground as 70% solid slurry to obtain fine ores of less than 1.0mm diameter. The mill discharge is treated at the primary wet magnetic separator (9.16 mD × 1.8 mL × 2 Drums) to obtain concentrate ores with 61 to 62% of Fe and 2.18% of P_2O_5.

2-3-2 Secondary grinding/classification/secondary magnetic separation

The concentrate iron ores are further ground for complete liberation of iron minerals and gangue minerals and are treated at the secondary magnetic separators.

The ores are fed to the pebble mill (5.9 mD × 10.5 mL × 4,800 kWh) with closed loop of cyclone. The grinding media of the pebble mill is lump ores with 75 to 25 mm diameter and the over flow from the cyclone is treated at the secondary magnetic separator (0.916 mD × 2.4 mL × 6 Drums) to obtain concentrate with 66% of Fe and 0.92% of P_2O_5.

2-3-3 Reverse flotation

The concentrate is further processed at the reverse flotation to remove gangue as the froth.

The ores are mixed with soda ash, oleic acid collector and water glass are fed to the flotation cell (12.8 m^3 × 5 units) where the final iron ore concentrate is obtained as sink product and gangue minerals are removed as froth materials. The collector of oleic acid is mixed with fuel oil and caustic soda to form emulsion collector.

2-3-4 Scavenging

The froth is further processed at scavenging flotation cell (3.2 m^3 × 3 units), magnetic separator (0.916 mD × 0.9 mL) and ball mill (2.1 mD × 2.8 mL) to recover magnetite ores which is fed to the final concentrate.

The non-magnetics from the fourth magnetic separators are once again processed at the fifth magnetic separators to recover the residual magnetite minerals.

2-3-5 Thickening of iron ore and tails

The final iron ore concentrate is fed to the thickener (25 mD) and its spigot is taken as 65% slurry and sent to the pelletizing plant in Punta Colorada through pipeline (35km).

The overflow from the thickener is sent to the tail thickner and then sent to reclaimed water tank for reuses.

The iron ore concentrate is the quality with 68% of Fe and 0.32% of P_2O_5. The tails are sent to the tailing pond in Laguna Blanca and discarded.

The overall flowsheet and separation performance is shown in Figure IV-1. The raw materials available for the phosphate rock concentration is the mixture of non-magnetic tails from the primary and secondary magnetic separators. The analysis of the representative sample taken on October 6, 1983 is shown in Table IV-2, the non-magnetic tails has size distribution of 0.2 to 0.02mm and with 27.35% of Fe and 7.08% of P_2O_5.

CHAPTER 3. PELLETING OF IRON ORE CONCENTRATE

The pelletizing plant of HIPASAM is located in Punta Colorada, approximately a 35km east from Sierra Grande on the coast of the Atlantic Ocean. The iron ore concentrate is sent as 63% solid slurry in pipeline and processed at Punta Colorada for dewatering down to 10.5% water by the thickener (25 mD) and disk filter. The filter cake is pelletized at drum pelletizer (3.6 mD × 9.6 mL) to produce green pellet after mixing with bentonite, dolomite, calcite and hydrated lime as pelletizing agent. The green pellet is processed in the Midrex furnace (2.4 mD × 3.6 mH) by burning natural gas at the temperature of 1,350°. The retention time in the furnace is 8.0 hours to produce burned pellet. There are four identical trains of Midrex furnace with processing capacity of 75 TPH each.

The burned pellet product is directly loaded to the ocean going vessel with loading capacity of up to 70,000 Ton with 1,200 TPH loading speed or temporarily stored in the stock yard.

The overall material balance at the pelletizing plant is shown in Figure IV-2. The design capacity of the plant is 268 TPH and the actual production observed in July, 1983 was approximately 41% of the capacity.

At present, HIPASAM is carring out research and development study on the concentration of iron ore and its pelletizing process and product quality improvements at the bench test plant and also at the existing plant itself.

CHAPTER 4. PRODUCTION PLAN OF IRON ORE CONCENTRATE AND QUALITY

The whole facility of the HIPASAM, Sierra Grande and Punta Colorada has been completed in 1979 and the first shipment of the iron ore pellet was made from Punta Colorada on September 10, 1979. The design capacity is 2,000,000 TPY and the product is scheduled to supply at the blast furnace steel plant of SOMISA and the direct reduction steel plant of DALMINE and ACINDAR in Argentine.

The production performance and projection are summarized as follows;

PRODUCTION OF IRON ORE CONCENTRATE, HIPASAM, ARGENTINE

Year	Production
1979 (Historical)	79,800 TPY
1980	133,100
1981	297,200
1982	620,200
1983	800,000
1984 (Plan)	1,000,000
1985	1,500,000
1986	1,500,000
1987	2,000,000

At blast furnace of SOMISA, the iron ore pellet of HIPASAM is used as a mixture with the sinter produced from the imported iron ore from Brazil. The mixture ratio of pellet is 45% in 1983, however it will be increased up to 50% in the near future for the blast furnace (No. 1 and No. 2).

The feed ratio of HIPASAM pellet at the direct reduction plant at DALMINE and ACINDAR are estimated 20% of the total feed. Moreover if the new direct reduction plant of SIDERSUR in San Antonio Este with a design capacity of 550,000 TPY is completed in 1989 as is planned now, the demand of the iron ore pellet of HIPASAM will be increased greatly.

At present, a portion of product is exported to improve the capacity utilization, but the production of the plant will go up to the design capacity before 1990, and the output of the non-magnetic tails, which will be used as raw material for the phosphate rock concentration, would be reached also to the design capacity and quality.

As HIPASAM is now implementing the process and product improvement plans to produce low P_2O_5 pellet (P_2O_5: 0.05%) for the direct reduction uses, the quality and quantity of tails for the production of phosphate rock in the future will be improved.

-- The Table IV-3, the product specification of iron pellet of HIPASAM is shown in comparison with the purchasing specification of the SOMISA, ACINDAR and DALMINE. The major features of HIPASAM pellet is a little higher in P_2O_5, wider size distribution and lower crushing strength.

CHAPTER 5. PHOSPHATE ROCK CONCENTRATION TEST

5-1 Outline

The phosphate minerals, removed during the iron ore concentration process at HIPASAM, Sierra Grande is mostly discarded as non-magnetic tails and flotation tails. Approximately 82.5% of phosphate is in non-magnetic tails and the rest is in flotation tails. Therefore, it was considered reasonable to make study of phosphate rock concentration from the non-magnetic tails.

A preliminary tests in 1972 at HIPASAM revealed that phosphate rock with P_2O_5, 32.7% and Fe, 5.7% quality and a recovery of 62.5% of P_2O_5 are obtainable from the non-magnetic and flotation tails.

It is also reported that the phosphate rock concentration are operated at SSAB, Grängesberg (75,000 TPY) and KLAB, Kiruna (200,000 TPY), both in Sweden and a small scale operation in Pea Ridge, the USA, using the tails of iron ore concentration plants. The performance in Sweden is to concentrate phosphate rock with P_2O_5, 36 to 39% and Fe 0.4 to 0.7% quality and a recovery of approximately 90% of P_2O_5.

In the study, the representative sample of non-magnetic tails of 500 kg weight has been taken at HIPASAM, Sierra Grande on October 6, 1983 and the concentration test and mineralogical study were carried out in Japan. A comparative mineralogical study was also undertaken on the tails and extracted phosphate rock of SSAB, Grängesberg, Sweden.

The phosphate rock concentration test in Japan indicates that by grinding and flotation process of non-magnetic tails, it is possible to extract phosphate rock with P_2O_5, 35 to 36% and Fe, 5 to 6% quality and with a recovery of P_2O_5 of 55 to 59% as an overall performance.

Based on the experimental test, the design criteria for the conceptual design of the phosphate rock concentration plant are established as follows;

- Phosphate Rock Quality :
  - P_2O_5 35.65%
  - Fe 5.80%
- Recovery :
  - P_2O_5 55.50%
- Design Capacity :
  - Phosphate Rock 100,000 TPY (336.7 TPD)
  - P_2O_5 35,650 TPY (120.0 TPD)

At the same concentration conditions, a representative sample of phosphate rock of 15 kg weight were produced for the evaluation tests for the production of seven alternatives of phosphate fertilizer.

parative data of non-magnetic tails and phosphate rock from Sierra Grande, Grängesberg and Kiruna are shown.

The characteristics of phosphate rock from Sierra Grande are its high residual iron content and also its smaller particle size in comparison with those of Grängesberg or Kiruna. It is generally accepted that phosphate rock for internationally tradable commodity has quality of over 30% of P_2O_5 and less than 1.0% of Fe. The range of impurity of iron, aluminum and magnesium in the phosphate rock is higher than any other phosphate rock commercially consumed at present for the production of phosphate fertilizer in the world. Therefore, it was considered impossible to evaluated the phosphate rock quality for the production of phosphate fertilizer without evaluation test to judge the applicability of process, raw material consumption, process plant investment, product quality for solubility of P_2O_5 and also physical properties as tradable phosphate fertilizer commodity.

The minimum residual iron level achieved in experimental scale by the multi-stage cleaner flotation is 2.4% and by the high gradient magnetic separation is 1.84% at 20,000 Gauss magnetic fields.

5-2 Phosphate Rock Concentration Test

The phosphate rock concentration test was carried out in Japan by using the representative sample tails taken at HIPASAM, Sierra Grande on October 6, 1983.

Judging from the preliminary trial tests, it was considered reasonable to concentrate phosphate rock by rougher flotation and multi-stage cleaner flotation. The details of test results are shown in Annex IV and their summary are highlighted hereunder.

5-2-1 Rougher flotation

The objective of rougher flotation is to recover P_2O_5 at higher rate from the non-magnetic tails and removal of iron is secondary consideration. The recovery of 90% of P_2O_5 and 30 to 40% of Fe has been targeted during the rougher flotation.

The major test items for rougher flotation are;

- Selection of flotation collector chemicals
- Degree of grinding prior rougher flotation
- Selection of pH condition
- Selection of dispersant

The test results show that the best rougher flotation performance was obtained by anionic fatty acid collector among others such as sulfates of petroleum and oleic acid. The collector of Lilaflot BS-130FT, -730F and -OS-130 of Keno Gard AB, Sweden showed excellent performances.

Generally by grinding the non-magnetic tails, the recovery of P_2O_5 is increased, however simultaneously the recovery of Fe is also increased, and it was concluded that there are optimal grinding for rougher flotation. The optimal range of pH is rather narrow around pH 10. The addition of water glass is effective for dispersant and also as depressant of iron minerals.

It was also confirmed that conventional magnetic separation, desliming and scavenger flotation are not so effective for the separation of P_2O_5 and Fe during rougher flotation.

5-2-2 Cleaner flotation

The froth concentrate at rougher flotation is of P_2O_5, 14.0% and Fe, 23.2% quality with a P_2O_5 recovery of 90%. The froth is further processed at cleaner flotation.

The flotation separation of phosphate minerals and iron minerals in the non-magnetic tails of Sierra Grande is rather difficult because the iron minerals and chlorite [$(Mg, Fe, Al)_6(OH)_8$ $(Si, Al)_4O_{10}$] are closely locked with apatites, and also a small amount of iron is homogeneously distributed in apatites which was confirmed by the electron probe micro analyzer (secondary electron image) observation.

Therefore, it is required to grind the ores extensively for the liberation of each crystal grains and also to depress the flotation of iron minerals and chlorite during the cleaner flotation. However, the Zeta potentials of apatites and chlorite are in a same range, and was found the complete separation of apatite and chlorite is rather difficult.

Various depressant were tried such as water glass, starch, dextrine, sodium hexameta phosphate or quebracho and was found that the addition of water glass and dextrine combination is the most effective for depressing the iron minerals and chlorite. The addition of quebracho or sodium hexameta phosphate was found not effective.

Regarding cleaner flotation steps, comprehensive test up to seven stage cleaner flotation were carried out and was found that the integration of rougher and five stage cleaner flotation is the most practical for the industrial plant. As for the basis of conceptual design of the phosphate rock concentration plant, following range of performance is expected:

- Phosphate Rock Quality:	
- P_2O_5	36 ± 0.2 to 35 ± 0.2%
- Fe	5 ± 0.2 to 6 ± 0.2%
- P_2O_5 Recovery:	55 ± 2.0 to 59 ± 2.0%

The overall performance of flotation and the basic conditions for the conceptual design of the phosphate rock concentration plant are shown in Table IV-6.

The detailed description of the test results are summarized in Annex IV.

5-2-3 HGMS

As the iron minerals and chlorite are closely locked each other as well as the floatability of apatites and chlorite are in a similar range and complete separation by flotation is impossible. Therefore, to investigate the minimum level of residual iron in phosphate rock, magnetic separation by the HGMS (High Gradient Magnetic Separation) was tried.

The flotation concentrate is used as feed and highly purified phosphate rock of P_2O_5, 39.55% and Fe, 1.84% quality was obtained. The test results are shown in Table IV-7.

Although the removal of iron from phosphate rock by HGMS is effective, but at a same time the loss of P_2O_5 is also higher resulting in the overall P_2O_5 recovery of 22.1%, therefore it is considered that HGMS is not practical for the industrial plant.

5-3 Mineralogical Study

A wide range of mineralogical investigation was made for the non-magnetic tails and extracted phosphate rock of Sierra Grande, Argentine and also Grängesberg, Sweden.

Major items investigated are;

- Chemical Analysis
- Particle Size Distribution Analysis
- Microscope Observation
- X-ray Diffraction
- Electron Probe Micro Analyer
- Infra Red Absorption

The detailed description of such investigation and observation are shown in Annex IV.

The major findings of the mineralogical study are summarized as follows;

(1) Major minerals of the phosphate rock is fluorapatite and hydroxyapatite.

(2) Besides the two apatites, two phosphate minerals are identified which contains iron and calcium as constituents and shows blue and brown color.

(3) Chlorite is also found in the phosphate rock. Chemical composition of chlorite is considered high in iron from the X-ray diffraction analysis.

(4) Apatite crystals are forming locked structure with iron minerals and chlorite. A portion of such minerals are of inclusion in apatite crystal.

(5) A small amount of iron is distributed homogeneously in apatites which is confirmed by the X-ray analysis (Electron Micro Probe Analyzer, Secondary Electron Image).

(6) Phosphate rock from Grängesberg contains only fluorapatite and chlorite association is not identified. Locked formation is also observed but with mostly iron minerals and amphibole.

The comparative description of the mineralogical study results are summarized in Table IV-8 and IV-9, and representative microscopic observation are shown in Figure IV-3.

Table IV-1 IRON ORE RESERVES AT SIERRA GRANDE, RIO NEGRO, ARGENTINE

(1) Reserves

	Reserves (Unit: Million Ton)			
	South	East	North	Total
Proved	113	6	20	139
Probable	100	4	20	124
Sub-total	213	10	40	243
Possible	-	-	-	500

The iron ore is mined at present from the south reserve, the design capacity of HIPASAM is 3.5 million TPY.

(2) Analysis of Ore in the South Researve

Chemical Analysis;

Fe	54.80 ± 1.57%
P	1.43 ± 0.057%
P_2O_5	(3.28)
S	0.44
SiO_2	5.95
Al_2O_3	4.85
CaO	3.27

(3) Minerals

Principle Minerals;

Magnetite	Fe_3O_4
Martite	Fe_2O_3
Hematite	Fe_2O_3

Secondary Minerals;

Chlorite	$(Mg,Fe,Al)_6(OH)_8(Si,Al)_4O_{10}$
Feldspar	$(Na,K)AlSi_3O_8$
Apatite	$3Ca_3(PO_4)_2Ca(OH,F)_2$
Lazulite	$2AlPO_4(Fe,Mg)(OH)_2$
Andalusite	Al_2SiO_5
Pyrite	FeS_2
Quartz	SiO_2
Iimonite	$2Fe_2O_33H_2O$
Mica	$(K,Na,Ca)(Mg,Fe,Li,Al)_2$ $(Al,Si)_4O_{10}(OH,F)_2$
Calcite	$CaCO_3$

Table IV-2 RAW MATERIAL CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION PLANT

1. Source: Non-Magnetic Tails from Magnetic Separator (Between 828/9 to 850) at Iron Ore Concentration Plant, HIPASAM, Sierra Grande, Rio Negro, Argentine

2. Specification:

-Analysis, Dry Weight	
Fe	27.53%
Fe (II)	13.78
Fe (III)	13.75
K_2O	0.67
Na_2O	0.23
MgO	1.14
CaO	3.93
Al_2O_3	14.23
P	3.09
P_2O_5	(7.08)
SiO_2	19.29
S	2.28
F	0.23
Cl	0.001
CO_2	0.16
-Size Distribution	
(+) 0.2 mm	5.0%
(+) 0.1	15.0
(+) 0.05	35.0
(+) 0.02	55.0
(+) 0.01	70.0
(+) 0.005	75.0
(+) 0.002	82.0
(-) 0.002	18.0
-Conditions	
Pressure	1.0 ata
Temperature	10.0°C
Solid Content	4.0%
Water Content	96.0
Specific Gravity	1.03

Table IV-3 IRON ORE PELLET SPECIFICATION AT HIPASAM, ARGENTINE
(Steel Production Process and Pellet Specification)

		* Blast Furnance		Direct Reduction					
		SOMISA Argentine	HIPASAM Argentine	ACINDAR Argentine	DALMINE Argentine	SIDERSUR Argentine	HIPASAM Argentine	CVRD Brazil	SAMARC Brazil
1. Chemical Analysis,%									
Total Fe,	Min	65.0	65.0	67.0	-	-	66.95	67.5	67.0
SiO_2,	Max	4.0	4.20	2.0	-	-	2.43	1.93	1.8
Al_2O_3,	Max	1.0	1.75	1.10	-	-	1.19	0.63	0.9
CaO,		2.0	0.95	1.10	-	-	0.68	0.76	2.8
MgO,	Max	0.5	0.27	0.30	-	-	0.40	0.10	2.8
S,	Max	0.08	0.003	0.006	-	-	0.002	0.002	0.001
P,	Max	0.05	0.10	0.045	-	-	0.063	0.035	0.035
$Na_2O + K_2O$,	Max	0.15	0.10	-	-	-	-	-	-
2. Physical Properties									
Tumble Test,	Min	92.0	93.0	-	-	-	-	-	-
Abrasion Test,	Mix	5.0	5.0	7.0	-	-	5.0	4.3	-
Crushing Strength,	Min	230	250	250	-	-	280	400	350
Below 80 kg,	%	5	3	-	-	-	-	-	-
Porosity		25	27	-	-	-	-	-	-
Size Distribution,%									
+ 19 mm		0	2.5	-	-	-	-	-	-
- 19 + 8 mm	Min	90	92.0	-	-	-	-	-	-
- 4.75 mm	Max	5	2.5	5.0	-	-	3.0	-	-
3. Metallurgical Properties									
Crushing Strength after Reduction	Min	45	55	40	-	-	45	82	-
Reducibility									
Index,	Min	60	61.3	-	-	-	-	-	-
Speed,	Min	0.5	0.5	-	-	-	-	-	-
Swelling,	Max	20	8	-	-	-	-	-	-
Disintegration,%									
+ 9.53 mm	Min	60	76.5	-	-	-	-	-	-
+ 6.35 mm	Min	65	83.5	-	-	-	-	-	-
- 0.5 mm	Max	20	6.7	-	-	-	-	-	-
Metallization		-	-		-	-	95.8	92.5	-
4. Remark									
Process, Source Capacity		Blast 2.0 MMTPY	Pelletizing 2.0 MMTPY	Midrex 0.35 MMTPY	Midrex 0.32 MMTPY	HYL 0.55 MMTPY	Test Production	Import	Import

Notes:
- No imported pellets from Brazil are used at SOMISA's blast furnaces.
- Present raw material mix in SOMISA's No. 1 blast furnace is 40% pellets and 60% sinter. Pellet ratio will be increased to 50% at the end of 1983.
- Future raw material mix in SOMISA's No. 2 blast furnace which will be started operations in 1984, will be approximately 50 % each of pellets and sinter.
- Prices of HIPASAM pellets are at the international level.

Table IV-4 ANALYSIS OF PHOSPHATE ROCK EXTRACTED FROM IRON ORE CONCENTRATION NON-MAGNETIC TAILS OF HIPASAM, SIERRA GRANDE, ARGENTINE

(1) CHEMICAL ANALYSIS

As Element	Weight Percent	As Oxide	Weight Percent	Equivalency for 100g Sample
P	15.56%	P_2O_5	35.65%	(-) 1.507
C (Carbonate)	0.09	CO_2	0.33	(-) 0.015
F	1.50	F	1.50	(-) 0.079
Cl	0.01	Cl	0.01	(-) 0.0005
OH	-	OH	(3.88)	(-) (0.2285)
S (Total)	-	S and Oxides	-	(-) -
S (Sulfide)	0.48	S	0.48	(-) 0.030
S (Sulfate)	-	SO_3	-	(-) -
Si	1.98	SiO_2	4.24	(-) 0.141
Fe (Total)	5.80	Fe Oxides	7.67	(+) 0.233
Fe (II)	4.36	FeO	(5.61)	(+) (0.156)
Fe (III)	1.44	Fe_2O_3	(2.06)	(+) (0.077)
Al	1.46	Al_2O_3	2.06	(+) 0.162
Mn	-	MnO	-	(+) -
Ca	31.66	CaO	44.30	(+) 1.580
Mg	0.22	MgO	0.36	(+) 0.018
Na	0.15	Na_2O	0.20	(+) 0.006
K	0.07	K_2O	0.08	(+) 0.002
Others	-	Others	-	-
Free Moisture	0.14	Free Moisture	0.14	-
Organics	-	Organics	-	-
Ignition Loss	1.68	Ignition Loss	1.68	
Total	65.95	Sub-total	102.58	(-) 2.001
		Adjustment for F	(-) 0.63	(+) 2.001
		Total	101.95	(+) 0.000

(2) PHYSICAL PROPERTY

Color			Gray
Size Distribution (Tyler Mesh and Millimeter)			
(+) 400 Mesh	(0.0370 mm)		15.9%
(+) 468.4	(0.0316)		18.4
(+) 677.8	(0.0219)		36.1
(+) 993.3	(0.0149)		52.5
(+) 1,309.7	(0.0113)		64.5
(-) 1,309.7	(0.0113)		35.4
			100.0
Density			3.27
Bulk Density	- Packed		1.67
	- Loose		1.27
Angle of Reponse			43.0°
Free Moisture of Filter Cake, %			13.0
Specific Surface Area, cm^2/gr			2,770

(3) FERTILIZER PROPERTY

	Weight Percent	Solubility Percent
Total P_2O_5	35.65%	100.0%
Nitric Acid Soluble P_2O_5	35.60	99.9
Hydrocholoric Acid Soluble P_2O_5	35.11	98.5
Citric Acid Soluble P_2O_5	7.96	22.3
Formic Acid Soluble P_2O_5	5.69	16.0
Ammonium Citrate Soluble (AV) P_2O_5 (Neutral)	0.00	0.0
Water Soluble P_2O_5	0.00	0.0

Notes:
- Sample tails (Fe=27.53%, P_2O_5=7.08%) were taken on October 6, 1983 at HIPASAM and concentration test and analysis were made at NIKKO Consulting and Engineering Co. Ltd., Japan in January, 1984. Recovery of P_2O_5 is 55.5%. Fertilizer property was determined at Nissan Chemical Industries, Ltd., Japan in March, 1984.
- Ignition loss is measured by heating at 900°C for 0.5 hours.
- Free moisture is measured by heating at 105°C for 5.0 hours.
- (OH) is estimated to keep balanced equivalency.

Table IV-5 ANALYSIS COMPARISON OF PHOSPHATE ROCK EXTRACTED FROM NON-MAGNETIC TAILS OF IRON ORE CONCENTRATION PLANTS

	Phosphate Rock		
	HIPASAM, Sierra Grande, Argentine	SSAB, Grängenberg, Sweden	LKAB, Kiruna, Sweden
Plant Completion Year	1990	1975	1981
Phosphate Rock Capacity, TPY	(100,000)	75,000	200,000
Phosphate Rock Product			
Analysis, %			
- P	15.56	16.92	15.70
- P_2O_5	(35.65)	(38.77)	(35.97)
- Fe	5.80	0.36	0.70
- Al	1.46	0.07	0.14
- Ca	31.66	38.10	35.02
- Mg	0.22	0.15	0.57
- F	1.50	4.80	2.80
- Cl	0.01	0.02	0.05
- CO_2	0.03	0.50	-
Size Distribution, %			
(+)0.037mm	15.90	37.50	38.50
(+)0.022	36.10	57.40	50.00
(+)0.011	64.50	80.00	70.00
Average Diameter, mm	0.028	0.049	0.030
Non-Magnetic Tails as Feed			
Analysis, %			
- P	3.09	4.98	4.60
- P_2O_5	(7.08)	(11.41)	(13.06)
- Fe	27.53	3.24	-
P_2O_5 Recovery, %	55.50	87.00(Winter) 90.00(Summer)	89.20

Notes: 1) HIPASAM; Hierro Patagonico de Sierra Grande, SAM, Argentine

2) SSAB; Svenskt Stål AB, Sweden

3) LKAB; Luossavaara Kirunavaara AB, Sweden

Table IV-6 CONCENTRATION OF PHOSPHATE ROCK BY FLOTATION

Fraction	Performance				
	Analysis, %		Recovery, %		
	Fe	P_2O_5	Weight	Fe	P_2O_5
Inputs;					
Non-Magnetic Tails	27.50	7.08	100.00	100.00	100.00
Outputs;					
Design Basis,					
-Phosphate Rock	5.80	35.65	11.02	2.32	55.50
-Tails	30.18	3.54	88.98	97.68	44.50
Range of Test Results,					
(H)-Phosphate Rock	5 ∓ 0.2	36 ± 0.2	10.80	2.00	55 ± 2
-Tails	30.20	3.60	89.20	98.00	45 ∓ 2
(L)-Phosphate Rock	6 ∓ 0.2	35 ± 0.2	11.90	2.60	59 ± 2
-Tails	30.40	3.30	88.10	97.40	41 ∓ 2
Flotation Extrapolation,					
-Phosphate Rock	2.40	41.02	0.00	0.00	0.00
-Tails	27.50	7.08	100.00	100.00	100.00

Notes: 1) Non-magnetic tails of the iron concentration plant, HIPASAM, Sierra Grande, Argentine is treated at grinding, rougher and five stage cleaner flotation using anionic fatty acid derivatives for flotation collector.

2) The concentration tests were carried out at the Technical Research Center of Nippon Mining Co., Ltd., Japan.

Table IV-7 CONCENTRATION OF PHOSPHATE ROCK BY HIGH GRADIENT MAGNETIC SEPARATORS

Fraction		Magnetic Field, Kilo Gauss	Performance				
			Analysis, %		Recovery, %		
			Fe	P_2O_5	Weight	Fe	P_2O_5
F-5,	Feed Phosphate Rock	0.0	5.74	36.00	100.0	100.0	100.0
N-01,	Non-Magnetics	1.0	4.88	36.54	86.3	73.3	87.6
M-01,	Magnetics	1.0	11.11	32.52	13.7	26.6	12.4
N-05,	Non-Magnetics	5.0	2.87	38.83	63.5	31.7	68.5
M-05,	Magnetics	5.0	10.52	30.15	22.8	41.7	19.1
N-20,	Non-Magnetics	20.0	1.84	39.55	36.2	11.6	39.7
M-20,	Magnetics	20.0	4.21	37.97	27.3	20.1	28.8

Notes: 1) Feed phosphate rock is flotation concentration product by rougher and five stage cleaner from non-magnetic tails of HIPASAM, Sierra Grande, Argentine which P_2O_5 recovery is 55.5%. The particle size is 30.4% for (+)0.02 mm and 69.5% for (-)0.02 mm fraction.

2) Fraction of N-01 is fed to obtain N-05 and M-05 and fraction N-05 is further fed to obtain N-20 and M-20.

3) The concentration tests were carried out at Nittetsu Mining Co., Ltd., Japan using the cyclic type HGMS (10-15-20), Sala Magnetics, Inc., USA.

4) Applied magnetic field is measured in terms of Gauss/cm.

Table IV-8 MINERALOGICAL STUDY RESULTS OF NON-MAGNETIC TAILS FOR PHOSPHATE ROCK CONCENTRATION

	HIPASAM Sierra Grande, Argentine	SSAB Grängesberg, Sweden
Major Minerals	Chlorite, Iron Minerals	Mica, Apatite, Amphibole, Fedlspar
Associated Minerals	Apatite, Quartz, Fedlspar, Mica, Garnet, Tourmaline	Iron Minerals, Quartz, Fluorite, Calcite, Garnet
Major Iron Minerals	Magnetite, Limonite, Hematite	Hematite, Magnetite
Major Phosphate Minerals	Fluorapatite, Hydroxyapatite Phosphate (Blue Colored) Phosphate (Brown Colored)	Fluorapatite
Liberated Apatite		
- 150/200 Mesh	-	Less than a Half
- 200/270 Mesh	Less than a Half	A Half
- 270/400 Mesh	A Half	More than a Half
Locked Minerals with Apatite	Iron Minerals Chlorite Phosphate (Blue Colored) Phosphate (Brown Colored)	Iron Minerals Mica, Amphibole, Quartz
Type of Locking	Simple to Complex Inclusion of Fine Iron Minerals in Apatite	Simple to Complex Inclusion of Fine Iron Minerals in Apatite
Iron Containing Minerals		
- Iron Minerals	Majority	Minority
- Chlorite	Majority	None
- Mica	Less (Muscovite)	Majority (Biotite, Philogopite)
- Amphibole	Minority	Majority
Chemical Analysis, %		
- Fe	27.53	10.48
- P	3.09	4.98
- P_2O_5	(7.08)	(11.41)
- CaO	3.93	17.41
- SiO_2	19.29	33.44
- Al_2O_3	14.23	7.05
Averaze Size, mm	0.028	0.049

Table IV-9 MINERALOGICAL STUDY RESULTS OF PHOSPHATE ROCK EXTRACTED FROM NON-MAGNETIC TAILS OF IRON ORE CONCENTRATION PLANT

	HIPASAM Sierra Grande, Argentine	SSAB Grängesberg, Sweden
Major Minerals	Fluorapatite Hydroxyapatite	Fluorapatite
Associated Minerals	Chlorite Iron Minerals	Calcite Amphibole
Liberated Apatite	Majority	Majority
Locked Minerals with Apatite	Iron Minerals Chlorite	Iron Minerals, Mica, Amphibole
Type of Locking	Complex, Inclusion of Fine Iron Minerals in Apatite	Complex, Inclusion of Fine Iron Minerals in Apatite
Elements in Apatite Detected by X-ray Microanalyzer	Majority; Ca, P Minority; Fe Not Detected; Mg	Majority; Ca, P Not Detected; Fe, Mg
Iron Containing Minerals	Iron Minerals, Chlorite, Mica	Iron Minerals, Mica, Amphibole
Chemical Analysis, %		
- Fe	5.80	1.10
- P	15.56	17.23
- P_2O_5	(35.65)	(39.48)
- CaO	44.30	52.50
- MgO	0.36	0.30
- F	1.50	2.80
- Cl	0.001	0.01
Average Size by Rosin-Rammler - Bennett Diagram, d', mm	0.022	0.054

Figure IV-1 SIMPLIFIED MATERIAL BALANCE FOR IRON ORE CONCENTRATION PLANT, HIPASAM, SIERRA GRANDE, ARGENTINE

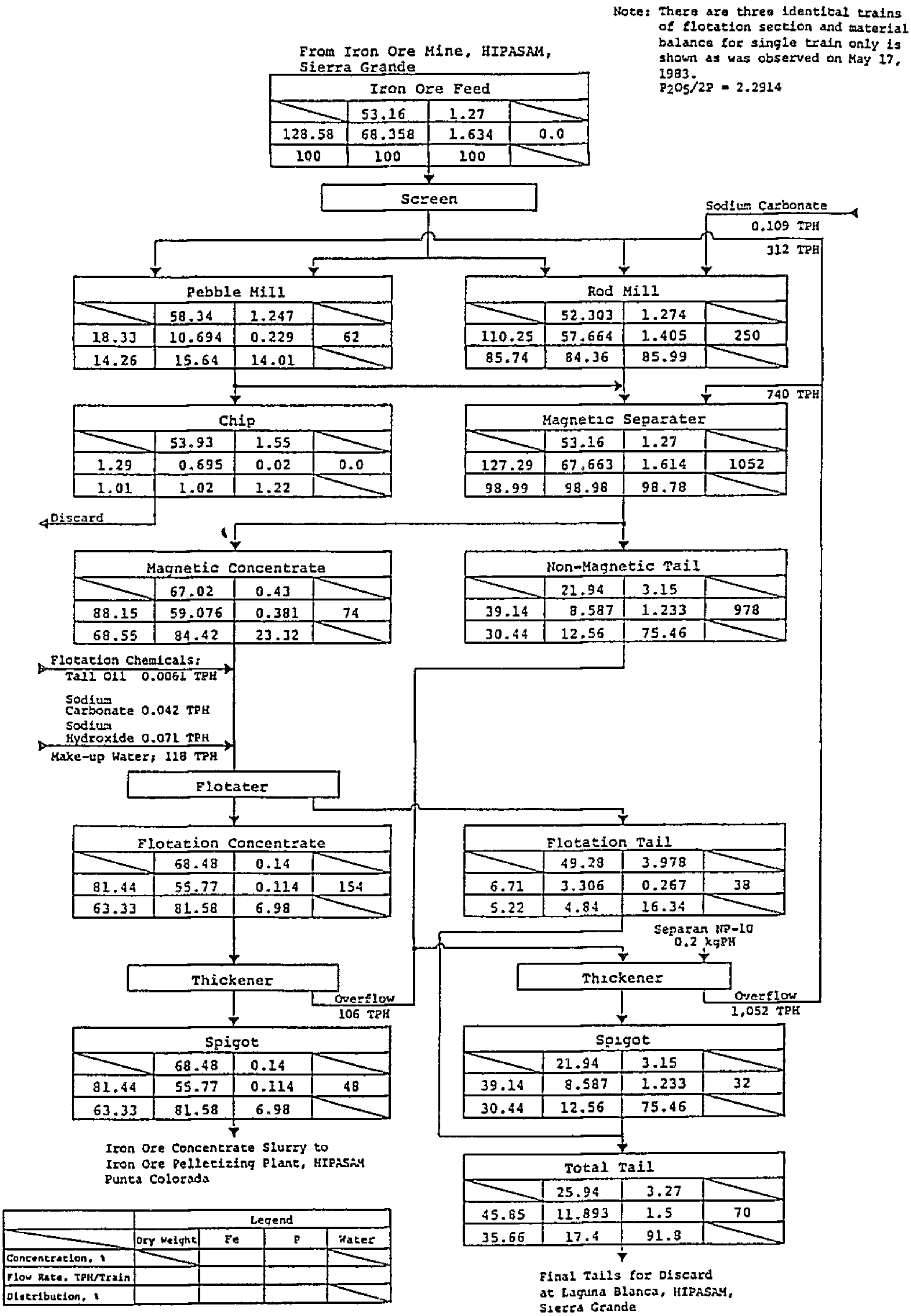
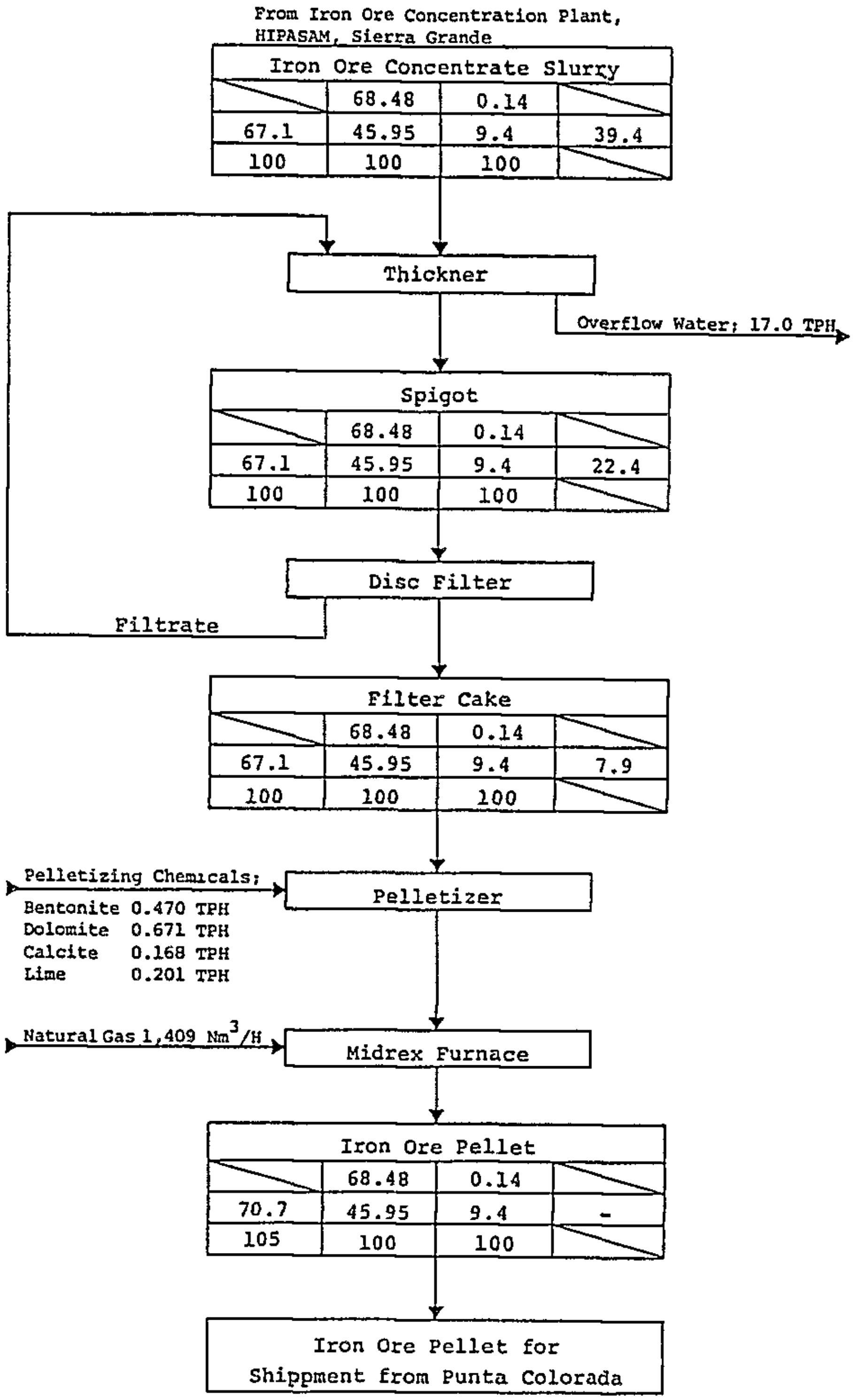


Figure IV-2 SIMPLIFIED MATERIAL BALANCE FOR IRON ORE PELLETIZING PLANT, HIPASAM, PUNTA COLORADA, ARGENTINE



Legend	Dry Weight	Fe	P	Water
Concentration, %				
Flow Rate, TPH/Train				
Distribution, %				

Note: There are four identical trains of pelletizing and furnace section and material balance for single train only is shown as was observed on July 01, 1983.

Figure IV-3 MICROSCOPE AND ELECTRON PROBE MICRO ANALYZER OBSERVATION OF NON-MAGNETIC TAILS AND PHOSPHATEROCK

Notes;

(1) Sample: - Non-Magnetic Tails of Iron Concentration Plant
- Phosphate Rock Extracted

(2) Source: - HIPASAM, Sierra Grande, Argentine - 1983
- SSAB, Grängesberg, Sweden - 1983

(3) Symbols of Minerals:

- am	Amphibole
- ap	Apatite
- B	Bubble (Contamination)
- bl-P	Phosphate Minerals (Blue Colored)
- br-P	Phosphate Minerals (Brown Colored)
- carb	Carbonate Minerals
- ch	Chlorite
- Fe	Iron Minirals
- fl	Fluorite
- fs	Feldspar
- gt	Garnet
- lm	Limonite
- mi	Mica
- g	Quartz
- tl	Tourmaline

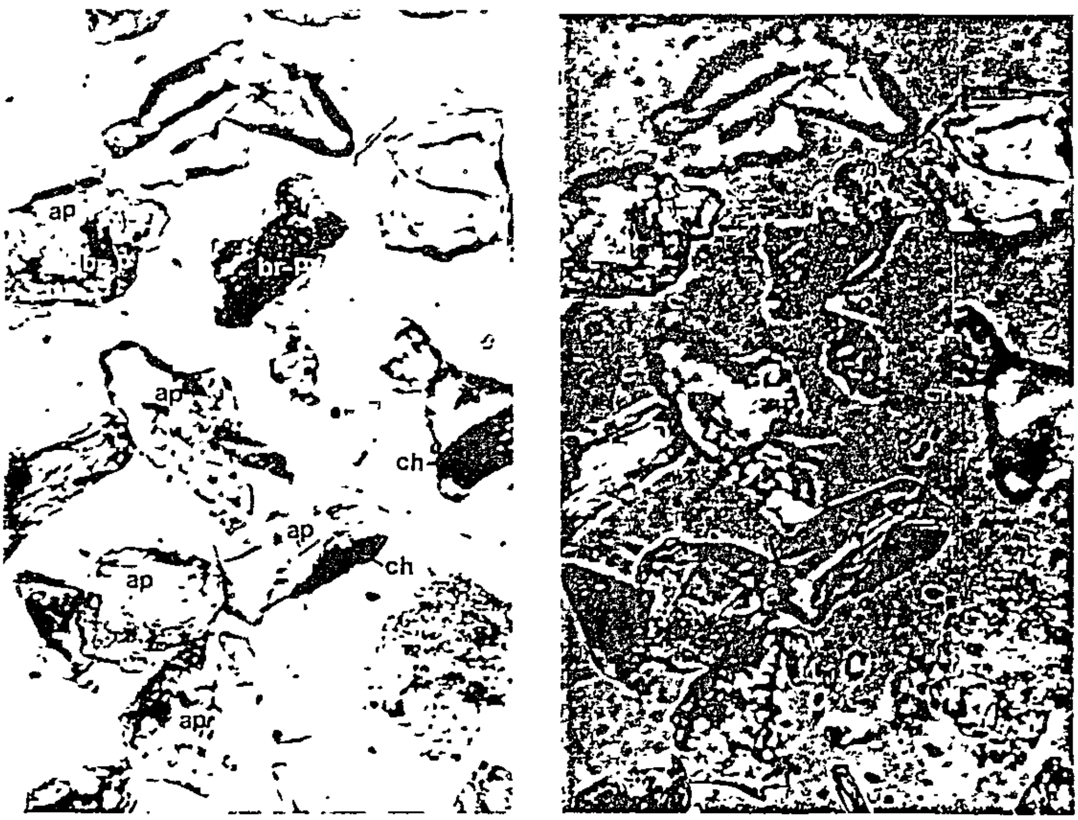
(4) Microscope Scale:
- (x)110, (x)220, (x)440

(5) Microscope Nicol Prism:
- Left Hand Side; Single
- Right Hand Side; Crossed

(6) Electron Probe Micro Analyzer
- Secondary Electron Image
- X-Ray Image (Energy Dispersed Method)
Ca-K alpha, Fe-K alpha,
Mg-K alpha, P-K alpha

Figure IV-3(1) Microscope Observation of Phosphate Rock, HIPASAM, Sierra Grande, Argentine

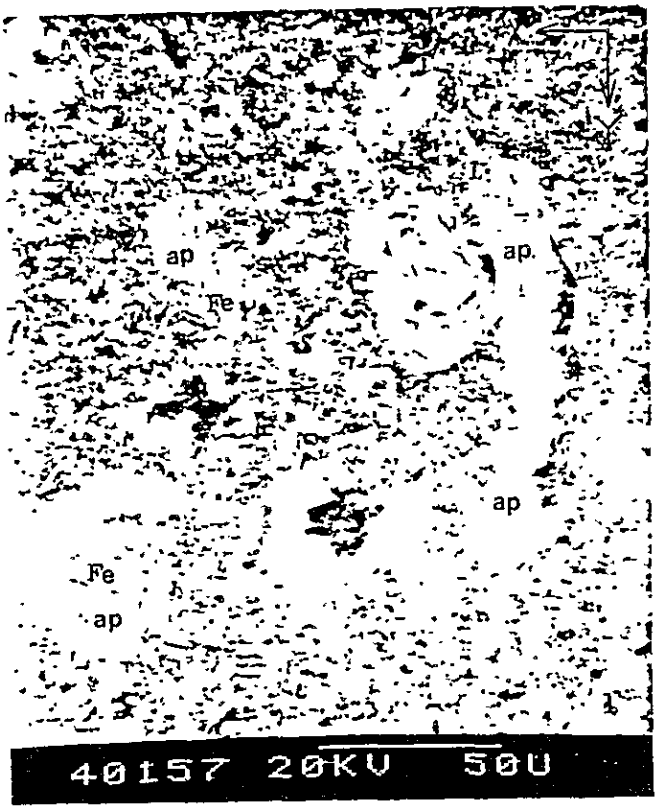
Scale: X220



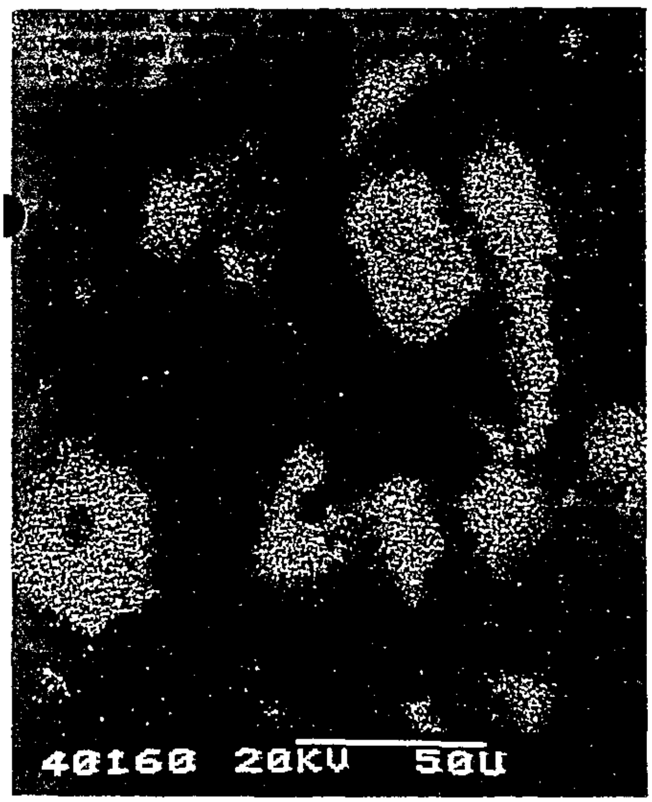
Scale: X220

Figure IV-3(2) Electron Probe Micro Analyzer Observation of Phosphate Rock, HIPASAM, Sierra Grande, Argentine

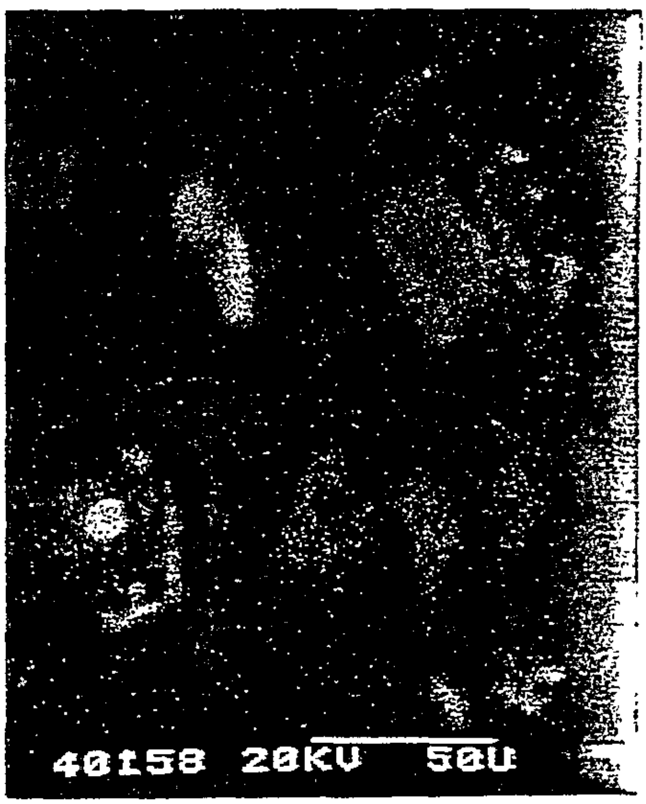
Microscope, Single Nicol
Scale: X-220



Secondary Electron Image

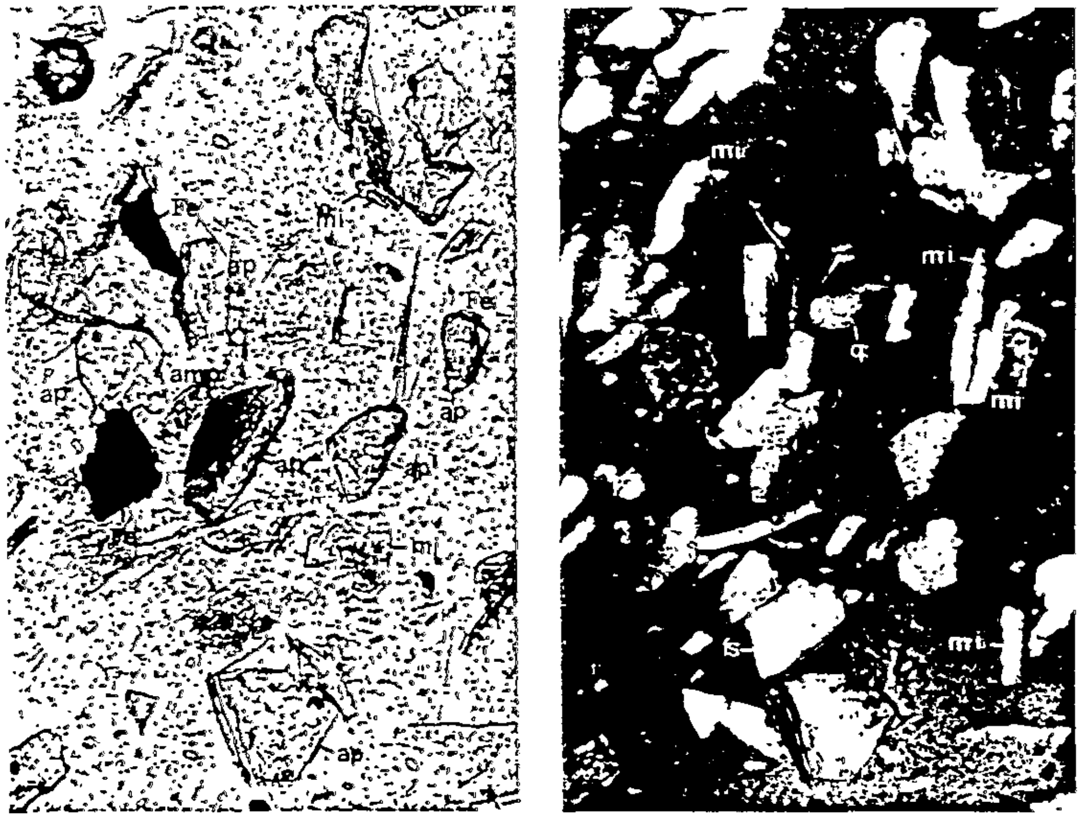


X-Ray Image, P-K alpha



X-Ray Image, Fe-K alpha

Figure IV-3(3) Microscope Observation of Phosphate Rock, SSAB, Grängesberg, Sweden

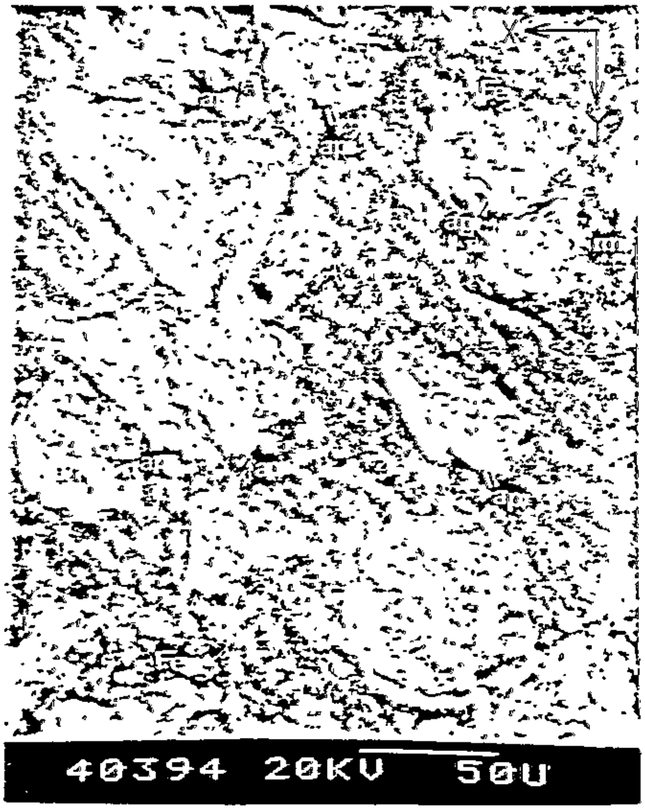


Scale: X220

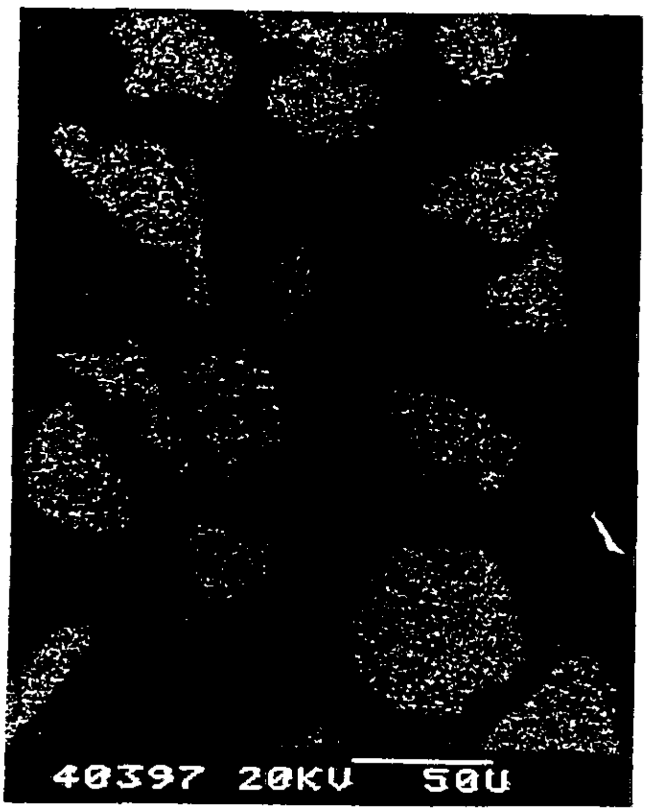
Scale: X220

Figure IV-3(4) Eletron Probe Micro Analyzer Observation of Phosphate Rock, SSAB, Grängesberg, Sweden

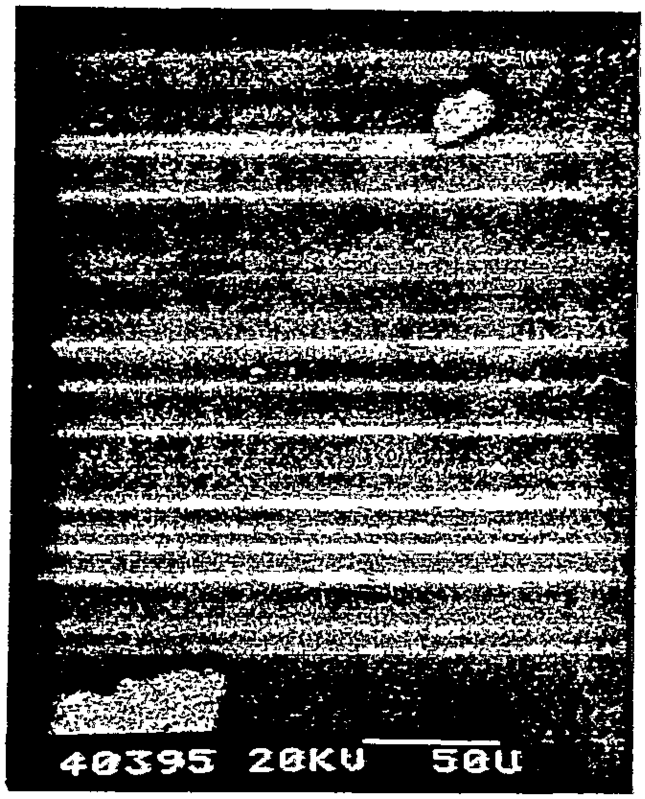
Microscope, Single Nicol
Scale: X-220



Secondary Electron Image



X-Ray Image, P-K alpha



X-Ray Image, Fe-K alpha

PART V

TECHNICAL STUDY FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER

PART V

TECHNICAL STUDY FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER

CHAPTER 1. INTRODUCTION

This Part of the report describes technical aspects of the proposed phosphate fertilizer project, and presents all the basic technical data necessary for the subsequent financial and economic study of the project.

The proposed phosphate fertilizer project in the Republic of Argentine consists of the following two successive projects;

i) the concentration and recovery of phosphate rock,

and

ii) the production of most suitable phosphate fertilizer(s) for the country on the basis of the phosphate rock thus concentrated and recovered, by processing with other raw materials and auxiliary materials.

Therefore, the technical study and the preparation of conceptual design have been made not only for each one of the phosphate rock concentration plant and production plants of alternative phosphate fertilizers preselected for the proposed study, but also for integrated projects of both the phosphate rock concentration and phosphate fertilizer production plants.

Due to unique mineralogical characteristics, the phosphate rock (apatite concentrate) concentrated and recovered from the iron ore tails discharged in the iron ore concentration plant of HIPASAM in Sierra Grande, as discussed in the previous Part IV, still contains relatively high percentage of iron as impurity, and at present in the world there are no commercial plants for the production of phosphate fertilizers that are operated based on such grade of phosphate rock. Since the quality of the recovered phosphate rock makes it impossible to establish design conditions for phosphate fertilizer plants based on experience of commercial operations, it was decided that in this study, experimental tests on evaluation of thus recovered phosphate rock have been carried out for each of the alternative phosphate fertilizer production processes and products. The conceptual design presented here has been made taking fully into account results of the laboratory tests.

In accordance with the terms of reference and also on the basis of the discussions made with the counterpart experts during the field survey in Argentine, three alternative site locations for plant construction and seven alternative phosphate fertilizers have been preselected, as enumerated below, for the purpose of comparison and final selection of optimum alternatives.

On the basis of the availability of the iron ore tails in Sierra Grande and also taking into account performance in the concentration and recovery of phosphate rock, the production scale of the project has been determined to be 100,000 TPY in terms of phosphate rock both produced in the concentration plant and successively consumed in the phosphate fertilizer plant. Therefore, there is no alternative considered for the phosphate rock concentration project. Plant capacities are designed assuming that all the plants can be operated, as average, at 90% rate of capacity utilization during an annual stream days of 330 days (i.e. 297 day at 100%).

The final selection of optimum combinations of alternatives for plant site and phosphate fertilizers has been made on the basis of qualitative and quantitative comparisons and evaluations as to problems for the production technologies of phosphate fertilizers, products quality of each phosphate fertilizer, availability and cost of other raw and auxiliary materials, and site factors etc. As a result, two alternative phosphate fertilizers have been selected and submitted to the subsequent financial and economic analysis of the proposed project.

(1) Alternative Site Locations

Symbol	Site Location	Abbreviation
PS - 1	Sierra Grande, Río Negro, Argentine	SG
PS - 2	San Antonio Oeste, Río Negro, Argentine	SAO
PS - 3	Bahía Blanca, Buenos Aires, Argentine	BB

(2) Phosphate Rock Conentration Plant

Symbol	Project Name	Abbreviation
PR - 1	Phosphate Rock Conentration Plant	PR

(3) Alternative Phosphate Fertilizers Plants

Symbol	Project Name	Abbreviation
PF - 1	Granuler Ground Phosphate Rock	GGPR
PF - 2	Fused Magnesium Phosphate	FMP
PF - 3	Single Super Phosphate	SSP
PF - 4	Triple Super Phosphate	TSP
PF - 5	Monoammonium Phosphate	MAP
PF - 6	Nitrophosphate and Calcium Ammonium Nitrate	NP/CAN
PF - 7	Nitrophosphate and Calcium Ammonium Nitrate	NP/CAN

CHAPTER 2. ALTERNATIVE SITE LOCATIONS, AND COCEPTUAL DESIGN CONDITIONS

2-1 Alternative Site Locations

On the basis of the discussions with the Argentine counterparts, and also taking fully into consideration availability and transportation of raw materials and auxiliary materails, supply of utilities, distribution of fertilizers to the market, etc., the following three alternative locations have been preselected in the proximity to Sierra Grande, where the iron ore tails are available, in the southern part of the Republic of Argenine:

- Sierra Grande, Río Negro
- San Antonio Oeste, Río Negro
- Bahía Blanca, Buenos Aires

The optimum site location will be selected from the above.

The non-magnetic iron ore tails, which are the basic starting material of the proposed project, will be available in Sierra Grande at a quantity of 921,621 TPY and in a form of 4.0% slurry. Since this volume of the tails can be concentrated to a 100,000 TPY of phosphate rock, it will be optimum to locate the concentration plant in Sierra Grande, unless otherwise any critical problems are encountered there. Moreover, it will be possible to discharge final waste-tails generated in the phosphate rock concentration process whose volume is 821,621, into the waste pond called "Laguna Blanca" situated also in Sierra Grande and presently used for the disposal of the iron ore tails themselves. Therefore, there is no attention needed for the problem of waste disposal in the case of Sierra Grande. In addition, there would be possibility for increasing the production of iron ore itself in Sierra Grande in future by supplying the above mentioned final waste-tails from the phosphate rock concentration plant (which are, in turn, concentrated in iron content and, on the contrary, reduced in phosphorus content, and very finely ground) after successful completion of research on their utilization. It is absolutely uneconomical to situate the concentration plant in any other locations than Sierra Grande.

As mentioned before, in this study, alternative phosphate fertilizers are to be considered; some of them requires a long-distance inland transportation of such material as serpentine at a large quantity from Córdoba in the northern part of the country, and others require imports of raw materials through the ports of San Antonio Oeste and Bahía Blanca. And, the country's market of phosphate fertilizer products is concentrated mainly in surrounding area of Bahía Blanca, north of Sierra Grande, and if the phosphate fertilizer plant is located in Sierra Grande, a round transportation of raw materials and product would take place in a same route between north and south. As to site location for the phosphate fertilizer plant, therefore, it will be better to situate it somewhere north to Sierra Grande. It has to be also emphasized that all the equipment needed for plant construction, both domestically purchased and imported from foreign countries, are to be transported through Buenos Aires, or Bahía Blanca or San Antonio Oeste. A brief comparison is made below for the three alternative site locations.

Sierra Grande has an advantage that the mining of iron ore and its processing is at present carried out there, and infrastructure and utilities facilities are available in addition to good housing conditions provided for more than 10,000 population. The most critical problem is the limited supply of water. It is judged that water requirement for the phosphate rock concentration plant will be available by saving water consumption as a whole in Sierra Grande with the development of small scale water sources under consideration. The limited suppliability of water, however, makes Sierra Grande unsuitable for the site location for the phosphate fertilizer plant which usually consumes a large amount of water.

The remoteness from the major consuming areas of fertilizers makes Sierra Grande further inattractive as site for the fertilizer plant. Naturally, the phosphate rock concentration should be installed within or as near as possible to the existing factory of HIPASAM.

San Antonio Oeste is located 134 Km north of Sierra Grande. San Antonio Oeste is adequate for the plant site for the phosphate fertilizers. This port of San Antonio Este was constructed for the purpose of exporting fruits and fruits juice. Its infrastructure is insufficient, though it has good conditions for the supply of utilities and the access to railway, road and ocean transportation. Since a direct reduction steel plant having a capacity of 550,000 TPY is contemplated by SIDERSUR in the area adjacent to the port, in which the company is at present applying for the purchase of an area of 800m × 1,000m of land, therefore, it is expected that the infrastructure will be improved there at around 1989 when the steel plant is supposed to be completed. There is sufficient supply of water, electric power, and natural gas. In this area of San Antonio Oeste, a sufficient land is available for industries, and in this stage of the study therefore there is no need for identifying a site spot within the proposed area. It is possible to acquire a proper site for the fertilizer plant, while watching the progress in the steel project of SIDERSUR. At present, San Antonio Oeste has a population of 9,000.

Bahía Blanca, a large city having a population of 180,000, is located 528 Km further north of Sierra Grande. In addition to the existence of a large commercial port, there is a sizable petrochemical complex, a compound fertilizer plant and machine shops, and a large scale industrial estate is provided there with sufficient provisions of infrastructure and utilities supply. Among advantageous conditions of Bahía Blanca as plant site for phosphate fertilizers, are the convenience of importing easily both raw materials and equipment, the proximity to the country's major consuming areas of fertilizers, and the direct access to the country's two main natural gas pipelines: one coming from Tierra del Fuego, and southern Santa Cruz called "Gasoducto del Sur", and the other from Neuquén, called "Gasoducto del Oeste". Bahía Blanca is in a position to be able to receive natural gas from both of the two main lines. It is noted however that the delivered price of natural gas in Bahía Blanca is higher than those in Sierra Grande and San Antonio Oeste, because Bahía Blanca is categrorized in Zona III where the price of natural gas is 1.467 (88/60) times higher than in Zona IV to which both Sierra Grande and San Antonio Oeste belong. Since there is sufficient land available in Bahía Blanca, there is no need for identifying at this moment a site spot for the phosphate fertilizer plant.

Detailed site conditions for each of the three proposed sites are summarized in Table V-1, in which a comparison is made for geographical, meteorological and soil conditions, the supply of utilities, infractructural conditions, railway and road transportation conditions, conditions of ports in proximity, and various investment and financial conditions.

Incidentally, recent experience of the construction of the port of San Antonio Este has clarified that the soil bearing value around there is generally low, and therefore further investigation is needed referring to the construction work of the direct reduction steel plant of SIDERSUR.

2-2 Conceptual Design Conditions for Plant Construction

Conceptual design conditions for each of the three alternative site locations for the phosphate rock concentration and phosphate fertilizers production plants are summarized in Table V-2. Table V-2 indicates meteorological conditions and utilities supply conditions for process design, and soil conditions for investment cost estimate. It is to be noted that the site location for the phosphate rock concentration plant has been determined to be in Sierra Grande.

The supply conditions of the basic starting material, which are the non-magnetic iron ore tails discharged in the iron ore concentration plant of HIPASAM in Sierra Grande, to the proposed phosphate rock concentration plan are shown in Table V-3. And the supply conditions of raw material phosphate rock, which is identical to the product of the phosphate rock concentration plant mentioned above, to the proposed phosphate fertilizers plants are indicated in Table V-4.

CHAPTER 3. CONCEPTUAL DESIGN OF PHOSPHATE ROCK CONCENTRATION PLANT

Conceptual design for the proposed phosphate roch concentration plant has been made on the basis of the experimental results of phosphate rock concentration tests and mineralogical investigations carried out for a representative sample of non-magnetic tails (in 500 Kg of quantity) collected from the iron ore concentration plant of HIPASAM in Sierra Grande on October 3, 1983, and also with the reference to the actual records and achievements in the commercial operations made in Sweden for the concentration and recovery of phosphate rock by means of flotation process using, as starting material, tails from magnetite concentration plant.

As discussed in the previous Part IV of the report, the experimental tests for concentration of the non-magnetic tails in Sierra Grande and their meneralogical investigations have resulted in distinguished differences in mineral structures between the two different sources of Sweden and Argentine, and clarified the concentration efficiency and performance is much unfavorable for the case of Sierra Grande.

The efficiency and performance in the concentration of phosphate rock from the tails in Sierra Grande can be evaluated in accordance with the three indicators: (1) overall recovery yield of P_2O_5 in phosphate rock product; and (3) residual Fe content in phosphate rock. According to the results of the experimental tests, a product of phosphate rock (apatite concentrate) having a quality of 35.65% P_2O_5 with 5.80% Fe content was produced by flotation at a overall P_2O_5 recovery of 55%. This level of concentration performance can be considered reasonable as basic condition for the conceptual design of the plant.

It has to be noted that a trial by means of HGMS treatment for further reducing iron content in the product phosphate rock resulted in a better quality of 39.55% P_2O_5 with greatly reduced Fe content of 1.84% at overall P_2O_5 recovery of only 22.0%, and this case is therefore judged not to be realistic from commercial point of view.

The conceptual design for the phosphate rock concentration is made therefore on the basis of the condition that the plant shall produce a 100,000 TPY of product at 54.64% overall recovery of P_2O_5 starting from 921,620.7 TPY of the tails in Sierra Grande. The process consists of a multi-stages flotation, so that the non-magnetic tails are firstly treated in a thickener, and then ground, followed by further concentration by 5-stages flotation and cleaning. The concentrated phosphate rock product is then filtered and dried to eliminate moisture, and finally recovered as finely ground phosphate rock. A 821,620.8 TPY of final waste-tails is also discharged from the plant.

The followings are major facilities included in the phosphate rock concentration plant:

Process Plant;	
- Phosphate Rock Concentration Plant	336.7 TPD
Utility Plant;	
- Electric Power Distribution	6,000.0 KWh/h
- Raw Water Supply	50.0 TPH
- Others	-
Storage and Material Handling Facility;	
- Phosphate Rock Storage	5,000 Ton
- Phosphate Rock Loading	80 TPH
Auxiliary Facility;	
- Administration Building	500 m^2
- Maintenance Shop and Storage	1,000
- Others	-

Requirements of utilities are estimated as follows:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Phosphate Rock, Bulk, Ton	1.00	14.03	336.8
Consumption;			
- Non-Magnetic Tails, Dry Solid, Ton	9.22	129.29	3,103.1
- Raw Water, Ton	0.78	11.00	264.0
- Electric Power, kWh	338.58	4,750.00	114,000.0
- Natural Gas, MMBTU-LHV	0.55	7.72	185.2
- Chemicals, USD-1983	12.50	175.36	4,208.7

It is to be noted that the consumption figures for electric power and chemicals are considerably high.

The plant requires about 40,000 m^2 of land within or adjacent to, the Sierra Grande factory of HPASAM. It takes 20 months from the award of contract to the mechanical completion of the plant. The Base Project Cost in terms of 1983 prices is estimated at US$33.65 million, and the personnel requirement for the operation of the plant is estimated at about 238 persons. A more detailed description on the conceptual design is presented in Annex V-1.

CHAPTER 4. ALTERNATIVE PHOSPHATE FERTILIZERS, AND CONCEPTUAL DESIGN FOR PHOSPHATE FERTILIZER PLANTS

4-1 Preselection of Alternative Phosphate Fertilizers

As described in the previous Chapter 3, the content of P_2O_5 in the phosphate rock recovered from the tails of Sierra Grande is 35.65%, and therefore as far as the P_2O_5 content is concerned, the product can be considered as high grade phosphate resources. Nevertheless, it has to be noted that it also contains 5.80% of iron, and the aggregated amount of impurities such as iron, aluminum and magnesium which cause unfavorable and harmful effects to process performance and quality of product phosphate fertilizers, reaches 10.09% in terms of their oxides.

On the other hand, the minimum quality standards for phosphate rock widely accepted and transacted in the international market are those which the P_2O_5 content is higher than 30% and the analysis of aggregated content of oxides of iron, aluminum and magnesium is less than 3.0%. All the commercial technologies for the production of phosphate fertilizers have been developed based on such grade of phosphate rock; and therefore establishment of process conditions, raw materials and utilities requirements, products qualities and specifications, and investment cost estimate, all of which have been made based on such grade of commercially available phosphate rock. In this study, therefore, laboratory tests of evaluation for the production of the alternative phosphate fertilizers have been conducted using the representative sample of phosphate rock recovered (15kg) from the concentration tests, with the purpose of obtaining additional data needed for the conceptual design and selection of most suitable alternative(s) for the proposed phosphate fertilizer project.

One of the most popular route for the production of phosphate fertilizers is one which solubilizes phosphate component contained in raw material phosphate rock by the reaction with sulfuric acid and simultaneously converts calcium component contained in phosphate rock to gypsum Among phosphate fertilizers classified into this category are single superphosphate (SSP), triple superphosphate (TSP), and ammonium phosphates (MAP and DAP). In addition to sulfuric acid as raw material, the production of TSP and MAP/DAP require (wet-process) phosphoric acid as intermediate. As described before in the previous Part III, since neither sulfuric acid nor sulfur is expected to be made available for the proposed phosphate fertilizer project, it is necessary to install a sulfuric acid plant for the production of such fertilizers as noted above.

Taking advantage of a special characteristic of very fine particle size of the recovered phosphate rock, experimental tests were also made for seeking possibilities of the direct application of the phosphate rock as in a similar form of Hyperphosphate. In addition, there are some thermal phosphate fertilizers manufactured through high temperature treatment of phosphate rock in electric or direct-fired furnace. Fused magnesium phosphate (FMP) is one of them and laboratory tests for its production were also made in a natural gas fired furnace.

Among other phosphate fertilizers are nitric phosphates which are of high solubility and are produced by the decomposition of phosphate rock by nitric acid, followed by separation of calcium nitrate. As discussed in Part III before, there is in the country no suppliability of either nitric acid or ammonia from which nitric acid is derived. In this case, therefore, two alternatives have been set up for the production of nitric phosphates: one based on imported ammonia, and the other based on the domestic production of ammonia from natural gas available in the country. And at the same time, laboratory tests have also been made for the production of nitric phosphates starting from the recovered phosphate rock sample. It is to be noted that nitric phosphates have more characteristics as nitrogen fertilizers. As to the utilization of byproduct nitrogen fertilizers from nitric phosphate process, ammonium calcium nitrate was considered. It is noted the production of ammonium nitrate is also possible in this case.

The evaluation of the phosphate fertilizers produced experimentally from the recovered phosphate rock sample is made in accordance with the methods of analysis specified by IRAM in the Republic of Argentine.

An overall material flow and balance is schematically shown in Figure V-1, for the phosphate rock concentration and all seven alternatives of phosphate fertilizers production.

Block process flow diagram is presented in Figure V-2 for each of the alternative phosphate fertilizers.

4-2 Experimental Tests on Phosphate Fertilizers Production Based on Recovered Phosphate Rock Sample

The special characteristics of the phosphate rock concentrated and recovered from the non-magnetic tails in Sierra Grande, as raw material for the production of phosphate fertilizers, can be specified below:

(a) Sufficiently high in P_2O_5 content
(b) High content of Fe as impurity
(c) Relatively high percentage of ferrous type of Fe as impurity
(d) Finely ground phosphate rock
(e) Low in organic impurities
(f) Low reactivity with acid

The above points (b), (c) and (d) are very peculiar characteristics to the phosphate rock of this project, as compared with sedimentary-origin phosphate rock in common trade in the international market and also in comparison with phosphate rock concentrated and recovered in Sweden. These peculiar characteristics make it difficult to evaluate its suitability as raw material for phosphate fertilizers only based on past experiences, and therefore require additional technical evaluation tests.

The experimental tests have been made by the following fertilizer manufacturing companies, however, there is no reason that the conceptual design should be restricted within their licensed technologies, because the tests have been conducted impartially and almost independently of their own processes:

(a) Hinode Chemical Co., Japan..............Fused Magnesium Phosphate.
(b) Nissan Chemical Co., Japan........ ..Phosphoric acid, Evaluation of byproduct gypsum, Concentration of phosphoric acid, Single superphosphate, Triple superphosphate, and Ammonium phosphate.
(c) Norsk Hydro as., Norway................Nitric phosphate.

4-2-1 Production test of fused magnesium phosphate (FMP)

Results of fused magnesium phosphate production test are presented in Table V-5 Since the citric acid soluble P_2O_5 in the product reaches almost 100% ($C\text{-}P_2O_5/T\text{-}P_2O_5$ is calculated to be 99.6%) and therefore it is concluded that in spite of high content of Fe impurity in the raw material phosphate rock, fused magnesium phosphate product with high $C\text{-}P_2O_5$ can be produced without any critical problem. By using open hearth furnace, finely ground phosphate rock can directly be converted to fused magnesium phosphate.

It is also confirmed that serpentine collected in Argentine can be used as raw material for the production of fused magnesium phosphate. Although any technically serious problems are not encountered, it is better to make an additional test at a scale of 1 ton of phosphate rock sample in order to reconfirm basic design conditions.

4-2-2 Production test of phosphoric acid

Results of phosphoric acid production test based on a Hemihydrate-Dihydrate process are presented in Table V-6. It is concluded through this test that it is possible to produce phosphoric acid of 30% P_2O_5 concentration with 5.0% of excess sulfuric acid at 97.5% recovery of P_2O_5 from the phosphate rock. It is noted that the excess sulfuric acid concentration in the product phosphoric acid should be maintained at a slightly higher level as compared with in the case of commercial phosphate rock for which about 3% of excess sulfuric acid is added. Byproduct gypsum, whose microscopic picture is presented in Figure V-3, has good filtrability and fair quality

Judging from the above results, it is also possible to produce phosphoric acid based on ordinary Dihydrate process without any critical problems for plant design. However, Himihydrate process is not suitable for this phosphate rock, becasue of high viscosity of the product acid.

In order to reconfirm the design conditions, it is better to conduct an additional test for phosphoric acid production at a scale of 1 ton of phosphate rock sample.

4-2-3 Concentration test of phosphoric acid

Filter acid from phosphoric acid plant having generally 30% of P_2O_5 is usually concentrated up to 40 to 54% P_2O_5 concentration and then used for the production of triple superphosphate and ammonium phosphates. The concentration test of the phosphoric acid indicates that the commercially applicable concentration level would be limited to about 40% of P_2O_5 due to increase of viscosity and precipitation of sludge.

The concentration was conducted at 90° C under vacuum pressure of (-) 0.855 ata. Sludge precipitation is 1.10% during 24 hours and considerable amount of postprecipitation is found. A 98% of iron content in the phosphate rock is dissolved and extracted into the product phosphoric acid, and it is considered that through the concentration of the product acid, dissolved iron precipitates as complex salts of ferric/ferrous phosphate and sulfate which forms sludge. Overall recovery of P_2O_5 for the integrated process of phosphoric acid production and concentration is 97%.

4-2-4 Production test of single superphosphate, triple superphosphate and monoammonium phosphate

Single superphosphate was produced by a mixing and reaction of the phosphate rock sample with sulfuric acid at 90° C for 1 hour, followed by aging at 50° C for 7 days, during which a change of physical properties and product quality were investigated.

It has been observed that the reactivity of the phosphate rock is low and the reaction product is in a state of slurry and as a result it is impossible to apply ordinary production process for single superphosphate. In addition, the quality of the product is very low as compared with commercial single superphosphate; the contents of soluble phosphate as Av-P_2O_5 and W-P_2O_5 to T-P_2O_5 are only 70.8% and 52% respectively, and free acid content is high. Generation of sulfur dioxide is also observed at the time of the reaction with sulfuric acid, owing to the reduction of sulfuric acid by ferrous type iron existing in the phosphate rock.

Triple superphosphate was produced by mixing and reacting the phosphate rock sample with concentrated phosphoric acid (40% P_2O_5) at 90° C for 1 hour, followed by aging at 50° C for 7 days, during which a change of physical properties and product quality were investigated.

As in the case for single superphosphate, it has also been observed that the reactivity with phosphonic acid is low and the reaction product is in a state of slurry, and it is impossible to apply usual production process for triple superphosphate.

The product quality is much inferior to those commercially available; the Av-P_2O_5/T-P_2O_5 and W-P_2O_5/T-P_2O_5 are 70.8% and 65 5% respectively, and the free acid content is high.

Monoammonium phosphate was produced by the neutralization reaction of the concentrated phosphoric acid sample (40%) with gaseous ammonia, followed by drying. Physical properties and quality of the product were, then, investigated. Due to such impurities as iron contained in the phosphoric acid, the content of nitrogen and phosphate in the product is relatively low as compared to ordinary monoammonium phosphate fertilizer; it is recorded that Av-P_2O_5/ T-P_2O_5 and W-P_2O_5/T-P_2O_5 in the product are 98.1% and 65.0%, respectively. Moreover, W-N/T-N is recorded to be 76.1%. This is considered because of the formation of insoluble complex salts of ammonium ferric (or ferrous) phosphates, etc. at the time of neutralization of phosphoric acid by ammonia.

It is better to carry out an additional test at a scale of 1 ton of the phosphate rock sample, for the purpose of reconfirming basic design conditions for the production of those phosphate fertilizers.

4-2-5 Production test of nitric phosphates (NP/CAN)

Nitric phosphates were produced by the reaction of the phosphate rock sample with 60% nitric acid, followed by the crystallization and separation of calcium nitrate by means of cooling of the decomposition reaction products.

It is observed that the decomposition reactivity of the phosphate rock with nitric acid is good without much forming, and there is a generation of nitrogen oxides gas which may be attributable to the effect of ferrous type of iron.

The nitric acid insolubles, which amount to 4.59%, do not cause much problems for the process design. The transfer of such impurities as Fe, Al, and Mg originally brought with the phosphate rock to the product nitric phosphates are recorded to be 69% for Fe, 73% for Al and 90% for Mg, respectively.

This low level of extraction of iron by nitric acid contributes to the guard from lowering the product quality in terms of W-P_2O_5 content. It is noted the level of extraction of iron by sulfuric acid is recorded to be 98%.

Crystallization of calcium nitrate by cooling is also favorably made with a proper rate of crystallization and crystal growth.

Certain measures will have to be taken for the treatment of NOx gas generated at the reaction with nitric acid. It is concluded that the phosphate rock can be utilized for the production of nitric phosphate without any critical problems.

In this case also, it is better to conduct an additional test at a scale of 1 ton of the phosphate rock sample.

4-3 Conceptual Design for Phosphate Fertilizer Plant

On the basis of the results of experimental tests made for evaluations of the phosphate rock sample concentrated and recovered from the non-magnetic tails available in the iron ore processing plant of HIPASAM in Sierra Grande, conceptual design of the phosphate fertilizer production plant for each of the alternative phosphate fertilizers has been made as to requirements of raw materials and utilities, production capacity of the product, necessary equipment and facilities, product quality and specifications, etc. In addition, for the finally selected alternatives as most adequate phosphate fertilizer(s) for the country, investment cost estimate, project implementation schedule, and organization and personnel requirements have been prepared in order to be provided as a basis for the subsequent financial and economic analysis of the proposed phosphate fertilizer project in the Republic of Argentine.

4-3-1 Conceptual design for granular ground phosphate rock production plant (PF-1, GGPR)

Conceptual design is made by taking into account the results of production test based on the phosphate rock sample and of solubility test of P_2O_5 in the product, as well as by referring operational performance in the Hyperphosphate plant of AGROMAX in Uruguay and past experience in the production of Hyperphosphate also by AGROMAX in Argentine. The results are summarized in Annex V-2.

Despite the phosphate rock sample is very finely ground, the product is low in reactivity and solubility An analysis of different types of P_2O_5 in the product indicates that C-P_2O_5/ T-P_2O_5 and F-P_2O_5/T-P_2O_5 are only 22.4% and 15.9% respectively, and there is no content of Av-P_2O_5 and W-P_2O_5, while T-P_2O_5 is recorded to be 33.87%.

The conceptual design is based on the annual production of granular ground phosphate rock of 103,177.8 TPY starting from 100,000 TPY of the phosphate rock. The followings are major equipment and facilities for this plant:

Process Plant,	
- Granular Ground Phosphate Rock	347.4 TPD
Utility Plant;	
- Electric Power Receiving	2,000.0 kWh/h
- Natural Gas Receiving	0.5 MMSCFD
- Raw Water Treatment	200.0 TPD
- Steam Generation	0.3 TPH
- Waste Water Treatment	200.0 TPD

Storage and Material Handling Facility;	
- Phosphate Rock	10,000 Ton
- Product	35,000 Ton
- Product Bagging	100 TPH
Auxiliary Facility;	
- Administration Building	750 m^2
- Maintenance Shop and Storage	1,000
- Others	-

Requirements of raw materials and utilities needed for the operation of this plant are estimated as follows:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Granular Ground Phosphate Rock, Bulk, Ton	1.00	14.48	347.4
Consumption;			
- Phosphate Rock ($P2O5$; 35.65%), Ton	0.96	13.89	333.3
- Potassium Chloride (W-K2O; 60.00%), Ton	0.05	0.74	17.7
- Electric Power, kWh	42.50	615.19	14,764.5
- Water, Ton	0.16	2.32	55 6
- Steam, Ton	0.01	0.19	4.5
- Natural Gas, MMBTU-LHV	0.48	0.88	165.0

Although this alternative of phosphate fertilizers has an advantage that it requires only a small amount of investment cost and auxiliary materials, however, it is noted its low quality is of great defect.

As to the plant location, there is not much difference among three alternative sites which are Sierra Grande (PS-1), San Antonio Oeste (PS-2) and Bahía Blanca (PS-3), because there is no significant difference between the volumes of raw materials and the volume of product and the plant consumes a small amount of utilities. Total land requirement is estimated at 50,000 m^2. The details of the conceptual design are shown in Annex V-2.

4-3-2 Conceptual design for fused magnesium phosphate production plant (PF-2, FMP)

Conceptual design has been made on the basis of the experimental test carried out for the production of fused magnesium phosphate starting from the phosphate rock sample, and also taking into account operational performance in fused magnesium phosphate plants in Japan. The results are presented in Annex V-3.

Although there is no special technical problem encountered in ordinary process, cares should be taken for mixing uniformly surpentine with the phosphate rock which is to be supplied in very fine particles. An analysis of the product results in 20.68% of T-P_2O_5, and C-P_2O_5/T-P_2O_5 and F-P_2O_5/T-P_2O_5 being 98.2% and 44.8% respectively.

The conceptual design is based on an annual production volume of 168,993 TPY starting from 100,000 TPY of the phosphate rock. The followings are major facilities of the plant:

Process Plant;	
- Fused Magnesium Phosphate	569.0 TPD
Utility Plant;	
- Electric Power Receiving	5,000.0 kWh/h
- Natural Gas Receiving	5.0 MMSCFD
- Raw Water Treatment	4,000.0 TPD
- Waste Water Treatment	4,000.0 TPD
Storage and Material Handling Facility;	
- Phosphate Rock	10,000 Ton
- Product	60,000 Ton
- Product Bagging	160 TPH
Auxiliary Facility;	
- Administration Building	750 m^2
- Maintenance Shop and Storage	1,000
- Others	

Requirements of raw materials and utilities needed for the plant operation are estimated below:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Fused Magnesium Phosphate	1.00	23.71	569.0
Consumption;			
- Phosphate Rock (P2O5; 35.65%), Ton	0.59	14.03	336.7
- Serpentine (MgO: 35.60%) Ton	0.508	12.04	289.0
- Electric Power, kWh	155.50	3,674.74	88,193.8
- Raw Water, Ton	5.60	132.76	3,186.4
- Natural Gas, MMBTU-LHV	6.05	143.43	3,442.4
- Brick for Repair, Ton	0.01	0.24	5.7
- Lime for Waste Water Treatment, Ton	0.02	0.47	11.4
- Fertilizer Bag, 50 kg Net, Sheet	20.20	478.90	11,493.6

In addition to phosphate rock, a large amount of serpentine is needed for the production of fused magnesium phosphate. Since serpentine is supposed to be supplied from Córdoba and the product, on the other hand, has to be consumed principally in the agricultural area surrounding Bahía Blanca, Sierra Grande (PS-1) is not suitable as plant site. San Antonio Oeste (PS-2) or Bahía Blanca (PS-3) is more adequate and economical. Total land requirement is estimated at 50,000 m^2. The details of the conceptual design are presented in Annex V-3.

4-3-3 Conceptual design for single superphosphate production plant (PF-3, SSP)

On the basis of results of the experimental test made for the production of single superphosphate starting from the phosphate rock sample, conceptual design has been made. The results are shown in Annex V-4.

The conceptual design is based on an annual production volume of 169,884 TPY using 100,000 TPY of the phosphate rock. The plant consists mainly of a 195.5 TPD sulfuric acid plant and a 572 TPD granular single superphosphate plant, as process plant. The followings are major facilities of the plant:

Process Plant;	
- Sulfuric Acid	195.5 TPD
- Single Super Phosphate	572.0
Utility Plant;	
- Electric Power Receiving	2,000 kWh/h
- Natural Gas Receiving	5 MMSCFD
- Raw Water Treatment	500 TPD
- Cooling Water Tower	14,400 TPD
- Waste Water	500 TPD
- Steam Generation	5 TPH
Storage and Material Handling Facility;	
- Phosphate Rock	10,000 Ton
- Sulfur	2,000 Ton
- Sulfuric Acid	1,000 Ton
- Product	60,000 Ton
- Product Bagging	160 TPH
Auxiliary Facility;	
- Administration Building	750 m^2
- Maintenance Shop and Storage	1,000 m^2
- Others	-

Requirements of raw materials and utilities needed for the plant operation are estimated as follows:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Granular Single Super Phosphate, Bagged, Ton	1.00	23.84	572.0
Consumption;			
- Phosphate Rock, Ton	0.59	14.03	336.7
- Sulfur, Ton	0.12	2.75	66.0
- Electric Power, kWh	69.23	1,650.00	39,600.0
- Raw Water, Ton	4.40	105.00	2,517.8
- Natural Gas, MMBTU-LHV	-	-	-
- Fertilizer Bag, 50 kg Net Sheet	20 20	281.46	1,554 7
- Catalysts and Chemicals, USD - 1983	0.275	5.55	157.3

Since the main raw materials are sulfur and phosphate rock and there is a considerable increase in the volume of product as compared to the volume of raw materials, San Antonio Oeste (PS-2) or Bahia Blanca (PS-3), which are located closer to the major fertilizer consuming area, are suitable as plant site. Total land requirement is estimated at 50,000 m^2. The details of the conceptual design are presented in Annex V-4.

4-3-4 Conceptual design for triple superphosphate production plant (PF-4, TSP)

Conceptual design has been made based on results of the experimental test for the production of triple superphosphate starting from the phosphate rock sample. The results are indicated in Annex V-5.

The conceptual design is based on an annual production volume of 72,260 TPY using 100,000 TPY of the phosphate rock. This plant consists mainly of a 191.5 TPD sulfuric acid plant, 81.9 TPD phosphoric acid plant and a 243.3 TPD triple superphosphate plant, as process plant. The followings are major facilities of this plant:

Process Plant;	
- Sulfuric Acid	191.5 TPD
- Phosphoric Acid as P_2O_5	81.9 TPD
- Triple Super Phosphate	243.3 TPD
Utility Plant;	
- Electric Power Receiving	2,000 kWh/h
- Natural Gas Receiving	5 MMSCFD
- Raw Water Treatment	2,000 TPD
- Cooling Water Tower	14,400 TPD
- Waste Water Treatment	1,000 TPD
- Steam Generation	5 TPH
Storage and Material Handling Facility;	
- Phosphate Rock	10,000 Ton
- Sulfur	2,000 Ton
- Sulfuric Acid	1,000 Ton
- Product	26,000 Ton
- Product Bagging	70 TPH
Auxiliary Facility;	
- Administration Building	1,000 m^2
- Maintenance Shop and Storage	2,400
- Others	-

Requirements of raw materials and utilities are estimated as follows:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Granular Triple Super Phosphate, Bagged, Ton	1.00	10.14	243.3
Consumption;			
- Phosphate Rock, Ton	1.38	14.03	336.7
- Sulfur, Ton	0.26	2.64	63.3
- Electric Power, kWh	139.74	1,416.66	37,000.0
- Raw Water, Ton	6.37	64.58	1,550.0
- Fertilizer Bag, 50 kg Net, Sheet	20.20	204.78	4,914.7
- Catalysts and Chemicals, USD-1983	0.27	2.73	65.5

Since the main raw materials are phosphate rock and sulfur and there is a decrease in the volume of product as compared to the volume of raw materials, Sierra Grande (PS-1), which is the closest to the site where the main raw material phosphate rock will be available, is expected to be suitable. Total land requirement is estimated at 97,500 m^2.

4-3-5 Conceptual design for monoammonium phosphate production plant (PF-5, MAP)

Conceptual design has been made based on experimental results of the production, concentration and neutralization tests of phosphoric acid starting from the phosphate rock sample. The results of conceptual design are indicated in Annex V-6.

The conceptual design is based on an annual production volume of 72,408.6 TPY using 100,000 TPY of the phosphate rock. This plant consists mainly of a 269.7 TPD sulfuric acid plant, a 115.3 TPD phosphoric acid plant, and a 234.8 TPD granular monoammonium phosphate plant, as process unit. The followings are major facilities included in this plant:

Process Plant;	
- Sulfuric Acid	269.7 TPD
- Phosphoric Acid	115.3 TPD
- Monoammonium Phosphate	234.8 TPD
Utility Plant;	
- Electric Power Receiving	2,000 kWh/h
- Natural Gas Receiving	5 MMSCFD
- Raw Water Treatment	3,000 TPD
- Cooling Water Tower	19,200 TPD
- Waste Water Treatment	3,000 TPD
- Steam Generation	5 TPH
Storage and Material Handling Facility;	
- Liquid Ammonia	2,000 Ton
- Phosphate Rock	10,000 Ton
- Sulfur	3,000 Ton
- Sulfuric Acid	19,200 Ton
- Phosphoric Acid, P_2O_5	600 Ton
- Product	14,000 Ton
- Product Bagging	65 TPH
Auxiliary Facility;	
- Administration Building	1,000 m^2
- Maintenance Shop and Storage	2,400 m^2
- Others	-

Requirements of raw materials and utilities are estimated as follows:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Granular Monoammonium Phosphate, Bagged, Ton	1.00	10.16	243.8
Consumption;			
- Phosphate Rock, Ton	1.38	14.03	336.7
- Liquid Ammonia, Ton	0.13	1.30	31 2
- Sulfur, Ton	0.37	3.76	90.2
- Electric Power, kWh	180.494	1,833.46	44,003.0
- Raw Water, Ton	6 6	67.08	1,609.0
- Fertilizer Bag, 50 kg Net, Sheet	20.20	205.20	4,927.7
- Catalysts and Chemicals, USD - 1983	0.39	3.92	94.0

The main raw materials are phosphate rock, imported liquid ammonia, imported sulfur. Although there is a decrease in the volume of product as compared to the volume of raw materials, there is no significant difference among three alternative plant sites, principally because of high transportation cost of ammonia to Sierra Grande. In the subsequent financial and economic study, therefore, Bahía Blanca has been chosen as representative site for this plant. Total land requirement is estimated at 97,500 m^2.

It is estimated that total personnel requirement is 298 persons, and base project cost is US$46.44 million in terms of 1983 prices. The construction of the plant requires 30 months from award of contract to mechanical completion, with additional 6 months up to the commence of commercial operation. The details of the conceptual design are presented in Annex V-6.

4-3-6 Conceptual design for nitric phosphates production plant (PF-6, NP/CAN)

On the basis of results of the experimental test conducted for the production of nitric phosphates starting from the phosphate rock sample, conceptual design has been made. The results of conceptual design are shown in Annex V-7.

The conceptual design is based on an annual production volume of nitric phosphates of 163,676.7 TPY with the byproduct ammonium calcium nitrate (CAN) of 139,708.8 TPY, starting from 100,000 TPY of the phosphate rock. This plant consists mainly of a 151.1 TPD carbon dioxide recovery plant, a 534 TPD nitric acid plant, a 551.1 TPD nitric phosphates plant and a 470.4 TPD ammonium calcium nitrate plant, as process unit. The followings are major facilities included in this plant:

Process Plant;	
- Carbon Dioxide Recovery	115.1 TPD
- Nitric Acid	534.0 TPD
- Nitrophosphate	551.1 TPD
- Calcium Ammonium Nitrate	470.4 TPD
Utility Plant;	
- Electric Power Receiving	9 MW
- Natural Gas Receiving	5 MMSCFD
- Raw Water Treatment	6,000 TPD
- Water Polisher	2,000 TPD
- Cooling Water Tower	7,000 TPH
- Steam Generation	45 TPH
- Waste Water Treatment	6,000 TPD
Storage and Material Handling Facility;	
- Phosphate Rock	10,000 Ton
- Product - NP and CAN	105,000 Ton
- Product Bagging	280 TPH
- Ammonia, Port Area,	10,000 Ton
, Plant Site	1,000 Ton
- Nitric Acid	9,000 Ton
Auxiliary Facility	
- Administration Building	1,000 m^2
- Maintenance Shop and Storage	2,500 m^2
- Others	-

Requirements of raw materials and utilities are estimated below:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Nitrophosphate, Ton	0.5395	22.96	551.1
- Calcium Ammonium Nitrate, Ton	0.4605	19.60	470.4
- Calcium Carbonate, Ton	(0.0947)	(4.03)	(96.7)
Average (23.19-11.22-0.0), Bagged, Ton	1.000	42.56	1,021.5
Consumption;			
- Natural Gas, MMBTU-LHV	2.73	116.20	2,788.8
- Liquid Ammonia, Ton	0.30	12.75	306.0
- Phosphate Rock, Ton (P_2O_5 35.65%)	0.33	14.03	336.7
- Catalysts and Chemicals, USD-1963	0.78	33.38	801.0
- Diatomaceous Earth, Ton	0.005	0.20	4.8
- Silica, Ton	0.002	0.09	2.1
- Coating Oil, Ton	0.0002	0.01	0.2
- Monoethanol Amine, Ton	0.00009	0.003	0.08
- Raw Water, Ton	5.47	232.98	5,591.5
- Electric Power, kWh	174.13	7,411.00	177,864.0
- Fertilizer Bag, 50 kg Net, Sheet	20.20	859.70	20,632.8

Since the main raw materials are phosphate rock and imported ammonia, and there is a great increase in the volume of products as compared to the volume of raw materials, Bahía Blanca, which is closen to the main fertilizer consuming area, is more suitable and economical as plant site, rather than Sierra Grande and San Antonio Oeste. Total land requirement is estimated at 135,000 m^2. The details of the conceptual design are presented in Annex V-7.

4-3-7 Conceptual design for nitric phosphate production plant (PF-7, NP/CAN)

As in the case of PF-6 described above, conceptual design has been made based on results of the experimental test carried out for the production of nitric phosphates starting from the phosphate rock sample. The results of conceptual design are indicated in Annex V-8.

The conceptual design is based on an annual production amount of nitric phosphates at 163,676.7 TPY with the coproduction of ammonium calcium nitrate at 139,708 8 TPY, using 100,000 TPY of the phosphate rock and also producing ammonia, nitric acid and carbon dioxide for the captive uses starting from the country's natural gas. Therefore, this plant consists mainly of a 303 TPD ammonia plant, a 534 TPD nitric acid plant, a 551.1 TPD nitric phosphates plant and a 470.4 TPD ammonium calcium nitrate plant, as process unit.

The followings are major facilities included in this plant:

Process Plant;	
- Ammonia	303.0 TPD
- Nitric Acid	534.0 TPD
- Nitrophosphate	551.1 TPD
- Calcium ammonium Nitrate	470.4 TPD
Utility Plant;	
- Electric Power Receiving	20 MW
- Natural Gas Receiving	20 MMSCFD
- Raw Water Treatment	10,000 TPD
- Water Polisher	3,000 TPD
- Cooling Water Tower	9,000 TPH
- Steam Generation	20 TPH
- Waste Water Treatment	10,000 TPD
Storage and Material Handling Facility;	
- Phosphate Rock	10,000 Ton
- Product - NP and CAN	105,000 Ton
- product Bagging	280 TPH
- Ammonia,	3,000 Ton
- Nitric Acid	9,000 Ton

Auxiliary Facility
- Administration Building 1,000 m^2
- Maintenance Shop and Storage 2,500 m^2
- Others

Requirements of raw materials and utilities are estimated below:

	Production and Consumption		
	Unit Product	Hourly	Daily
Production;			
- Nitrophosphate, Bagged, Ton	0.5395	22.96	551.1
- Calcium Ammonium Nitrate, Bagged, Ton	0.4605	19.60	470.4
- Calcium Carbonate, Bulk, Ton	(0.0947)	(4.03)	(96.7)
Average (23.19-11.22-0.0), Bagged, Ton	1.000	42.56	1,021 5
Consumption;			
- Natural Gas, MMBTU-LHV	9.82	417.72	10,025.9
- Phosphate Rock (P_2O_5 35.65%), Ton	0.33	12.47	336.7
- Catalysts and Chemicals, USD-1963	1.30	55.47	1,331.3
- Diatomaceous Earth, Ton	0.005	0.20	4.8
- Silica, Ton	0.002	0.09	2.1
- Coating Oil, Ton	0.0002	0.01	0.2
- Raw Water, Ton	7.06	300.40	7,210.1
- Electric Power, kWh	419.71	17,863.00	428,737.1
- Fertilizer Bag, 50 kg Net. Sheet	20.20	859.71	20,634.3

Since the main raw materials are phosphate rock and natural gas and there is a great increase in the volume of products as compared to the volume of raw materials, Bahía Blanca, a site location closer to the fertilizer consuming area, is generally preferable. It is noted in this project alternative, however, that the consumption of natural gas is also very high. And as discussed before, the natural gas price in Bahía Blanca is higher than those in Sierra Grande and San Antonio Oeste, both of which belong to the Province of Río Negro, and therefore a definite decision can not be made at this stage of the study.

A comparison and final decision among three alternative site locations for this alternative phosphate fertilizer production will be made by taking into account the price difference in natural gas in the subsequent financial analysis of the project. Total land requirement is estimated at 135,000 m^2.

This plant requires 440 persons, and base project cost is estimated at US$180.63 million in terms of 1983 prices. Total required duration to mechanical completion and to the commencement of commercial operation from award of contract is 30 and 36 months respectively. The details of the conceptual design are presented in Annex V-8.

CHAPTER 5. SELECTION OF PLANT SITE, AND CONCEPTUAL DESIGN FOR INTEGRATED PROJECT OF PHOSPHATE ROCK CONCENTRATION PLANT AND PHOSPHATE FERTILIZER PLANT IN ARGENTINE

5-1 Selection of Plant Site and Suitable Phosphate Fertilizers

The proposed project to be studied under the framework of this study is composed of the two independent and successive projects; the project for the concentration and recovery plant of phosphate rock (PC-1) starting from the non-magnetic tails discharged at present in the iron ore concentration plant of HIPASAM in Sierra Grande, Río Negro; and the project for the production plants of the alternative phosphate fertilizers (PF-1 to PF-7) based on thus recovered phosphate rock. In this study, therefore, conceptual designs have been made not only for each one of the above mentioned independent projects, but also for integrated projects consisting of the phosphate rock concentration and some of the selected alternative phosphate fertilizers, which should be considered as suitable and necessary ones to be submitted to the subsequent financial and economic analysis and evaluation.

Since there are two independent projects, one of which has seven alternatives, and there are three alternative site locations, there are theoretically 63 different types of combination of these factors, which may be considered as integrated project. As to the plant site for the phosphate rock concentration, however, there is no possibility other than that it is located in Sierra Grande, and as a result the total of different combinations is reduced to 21 cases, from which two of the most appropriate and necessary cases have been selected for the financial and economic analysis and evaluation as proposed integrated project, by taking into account such criteria as those for transportation and distribution costs needed for raw materials, auxiliary materials and products from sources of origin of materials up to final consuming areas of products, those related to efficiency and performance in the production of phosphate fertilizers, and those concerning quality evaluation of product fertilizers.

As to the criteria related with fertilizer distribution costs, it is necessary to determine a weighted average point of fertilizer consumption in Argentine, and it is assumed that it is in a great proximity to Bahía Blanca. Concerning the criteria for the products quality, references are made so as to be compared with those for internationally traded fertilizer commodities and with standards and regulations of IRAM in the country.

In order to select integrated projects, the following studies and discussions have been made.

5-1-1 Comparison of distribution costs for raw materials, auxiliary materials and products, and selection of plant site

On the basis of the conceptual design data presented in the previous Chapter 4 for each of the seven alternative phosphate fertilizer production plants, total distribution costs needed for all raw materials, auxiliary materials and products for each alternative plant site have been estimated in terms of Ton-km/Ton of product. The results are presented in Table V-7. Although in this calculation, natural gas, which is supplied by pipeline, is not taken into consideration, effects of the price difference of natural gas depending on the plant site are evaluated in the subsequent financial analysis. It has to be emphasized that, in general, such business as of fertilizers which transacts relatively low price of products, are economically affected greatly by costs of distribution.

Table V-7 can be utilized as one of the most determining criteria for the plant site selection. The following summarizes the favorable site of minimum distribution costs for each one of the alternative phosphate fertilizers, and percentage reductions of the distribution costs in these sites as compared with those in the other sites following those of minimum distribution costs:

SITE ALTERNATIVES CONPARISON

Phosphate Fertilizer	Site	Reduction of Ton-km/Ton, %
PF-1, GGPR	PS-3, Bahía Blanca	4.3
PF-2, FMP	PS-3, Bahía Blanca	37.4
PF-3, SSP	PS-3, Bahía Blanca	42.8
PF-4, TSP	PS-1, Sierra Grande	23.0
PF-5, MAP	PS-2, San Antonio Oeste	20.1
PF-6, NP/CAN	PS-3, Bahía Blanca	72.3
PF-7, NP/CAN	PS-3, Bahía Blanca	72.3

The results suggest that Bahía Blanca, which is the closest to the major fertilizer consuming areas, is mostly suitable, as plant site, for the phosphate fertilizer plant. It has to be noted that especially in the cases of the production of nitric phosphates (PF-6, and PF-7), Bahía Blanca has a great advantage over other sites. It is noted however that Sierra Grande in the case of TSP (PF-4), and San Antonio Oeste in the case of MAP (PF-5) are slightly advantageous over the others. In case of GGPR (PF-1), there is no significant difference and therefore Sierra Grande may be selected.

5-1-2 Evaluation of fertilizer product quality

On the basis of the experimental tests described in the previous Chapter 4, a comparison is made concerning product quality for the alternative phosphate fertilizers. The results are summarized in Table V-8. At the same time, fertilizer quality standards published by IRAM are noted. Since fused magnesium phosphate is not listed as fertilizer in the fertilizer regulations by IRAM and therefore there is no evaluation method indicated, it is assumed in this study that the analysis of citric acid soluble P_2O_5 being applied for Thomas slag, can also be applicable, because it can be considered as a similar fertilizer to fused magnesium phosphate.

Table V-8 indicates that only fused mangesium phosphate (PS-2, FMP) and nitric phosphates (PF-6 and -7, NP/CAN) satisfy the fertilizer quality standards by IRAM. Although the quality of monoammonium phosphate (PF-5, MAP) is at a slightly lower level than IRAM standards, all the other products remain far below the accpetable levels of standards; GGPR (PF-1) is low in formic acid soluble P_2O_5, and both SSP (PF-3) and TSP (PF-4), though they have a higher T-P_2O_5, are very low in water soluble P_2O_5 content, since W-P_2O_5 in the products reaches only 56.3% for SSP and 73.8% for TSP, respectively as compared with the standards in Argentine. In addition, free acid content both in SSP and TSP is higher. As to MAP (PF-5), it can be concluded that although the quality is slightly below the standards, it remains within a possible range of commercialization as phophate fertilizer for domestic use, by a modification of regulations. It is noted that MAP thus commercialized will be low both in water soluble phosphate and in water soluble nitrogen content.

For further reference, a comparative summary is made and presented in Table V-9 for the overall P_2O_5 yield for each of the alternative phosphate fertilizers.

5-1-3 Raw materials and utilities for production of phosphate fertilizers

Based on the experimental tests for manufacturing the phosphate fertilizers and the conceptual designs presented in Chapter 4, raw materials and utilities requirements have been summarized in Table V-10. The production of SSP (PF-3), TSP (PF-4) and MAP (PF-5) requires imported sulfur; in case of MAP, especially, a 27,000 TPY of imported sulfur is needed.

The production of FMP (PF-2) has an advantage that it does not require any imported material, because serpentine is supplied from Córdoba. The production of MAP (PF-5) and NP/CAN (PF-6 only) requires imported liquid ammonia; especially in case of PF-6, ammonia imports amount to 91,000 TPY. However, PF-7 (NP/CAN) has an advantage that it does not require any imports.

5-1-4 Selection of suitable alternatives of phosphate fertilizers

On the basis of all the technical studies and discussions made so far and also taking fully into account availabilities of raw materials as well as the characteristics of the country's agriculture and soil, two of the most suitable phosphate fertilizers have been selected, which are integratedly evaluated with the phosphate rock concentration plant project in Sierra Grande, financially and economically in the subsequent Parts.

Results of a qualitative comparative evaluation of the production of the seven alternatives are summarized in Table V-11. The followings are evaluation criteria:

- Availability of domestic raw and auxiliary materials, and foreign currency requirements needed for imported materials.
- Utilities consumption
- Product quality
- Water solubility of product phosphate fertilizers
- Physical properties
- Marketability of product fertilizers in Argentine
- Applicability and suitability of the phosphate rock to production technologies of phosphate fertilizers.

and

- Investment cost

It is concluded that the production of MAP (PF-5) and NP/CAN (PF-7), both of them are graded as "A" in overall evaluation in Table V-11, are two of the most suitable and adequate options for the country, and should be selected to be evaluated as integrated projects with the phosphate rock concentration plant in Sierra Grande in the subsequent financial and economic analysis.

It is noted that although FMP (PF-2) does not generate any problems in production technology, availability of serpentine, and in product quality, almost all agricultural area of the country is of alkaline soils. Therefore, it is ranked as "B" considering it can not become a substantive phosphate fertilizer in Argentine. In the case of PF-6 (NP/CAN) being also ranked as "B", higher attention has been given to the unfavorable fact that it requires a large amount of imported liquid ammonia despite the country is abundant in economical natural gas resources.

As to the plant site for the selected alternatives of phosphate fertilizers, either one of Bahía Blanca or San Antonio Oeste should be finally selected. However, taking into account all the discussions made so far and also for simplicity, conceptual design for integrated project is made only for Bahía Blanca. Since the main difference between the above two sites are encountered in natural gas price and distance to the fertilizer consuming area i.e. distribution costs of products, these factors will be able to evaluated in the financial and economic analysis so as to reach the final determination of the optimum site for the phosphate fertilizer plant.

5-2 Conceptual Design for Proposed Integrated Project of Phosphate Rock Concentration and Phosphate Fertilizer Plant

On the basis of the discussions presented in the previous section, the following two integrated projects have been proposed as schematically shown in Figure V-4.

The Case I integrated project consists of the phosphate rock concentration at an annual production of 100,000 TPY of phosphate rock, in Sierra Grande, the road transportation of the phosphate rock from Sierra Grande to Bahia Blanca, and the production of monoammonium phosphate (MAP) fertilizer in Bahia Blanca at an annual output of 72,400 TPY from the phosphate rock by using imported sulfur and liquid ammonia.

The Case II integrated project consists of the phosphate rock concentration at an annual production of 100,000 TPY of phosphate rock also in Sierra Grande, the road transportaion of the phosphate rock from Sierra Grande to Bahía Blanca, and the production of nitric phosphate (NP) at an annual output of 163,680 TPY with coproduction of ammonium calcium nitrate at 139,700 TPY in Bahia Blanca from the phosphate rock using natural gas.

Therefore, conceptual design for the integrated projects requires an integration of those presented in Annex V.

5-2-1 Conceptual design for Case I integrated project

The details of conceptual design for this case are presented in Annex V-1 and Annex V-6. This case requires 517 persons and the organizations as shown in Table V-12, and base project cost is estimated at US$80.09 million in terms of 1983 prices as indicated in Table V-13. Total period from award of contract to mechanical completion and to commencement of commercial operation is estimated to be 30 and 36 months respectively, as schematically shown in Figure V-5.

5-2-2 Conceptual design for Case II integrated project

The details of conceptual design are presented in Annex V-1 and Annex V-8. This project requires 659 persons and an organization as indicated in Table V-14. Base project cost is estimated at US$214.28 million in terms of 1983 prices as presented in Table V-15. Total duration from award of contract to mechanical completion and to commencement of commercial operation is estimated to be 30 and 36 months respectively as schematically shown in Figure V-6.

Table V-1 (1) SITE CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT, HIPASAM, ARGENTINE

Items	Project Site Alternatives		
	(PS-1) Sierra Grande, Río Negro	(PS-2) San Antonio Oeste, Río Negro	(PS-3) Bahía Blanca, Buenos Aires
GENERAL DESCRIPTION	Within the Iron Ore Concentration Plant of HIPASAM	Close to Muell Este-Puerto San Antonio and proposed site for SIDERSUR	Close to the Puertos de Bahia Blanca and Parque Industrial
LOCATION			
Longitude, West, Degree	65°20'	64°45'	62°15'
Latitude, South, Degree	41°30'	40°45'	38°45'
Height, Meter abbove Sea Level	268.0	10.0	10.0
CLIMATIC CONDITIONS			
Temperature, °C			
Absolute Maximum	37.0 (Feb)	41.7 (Jan)	41.9 (Jan)
Absolute Minimum	(-) 5.2 (Jun)	(-) 7.5 (Jun)	(-) 8.5 (Jun)
Average	13.5	-	14.8
Design, Maximum/Minimum	42.0 / (-) 10.0	42.0 / (-) 10.0	42.0 / (-) 10.0
Rain Fall, mm			
Annual	258.0	245.0	604.0
Monthly Maximum	44.7 (Dec)	29.0 (Oct)	88.0 (Mar)
Daily Maximum	54.5	-	-
Design, Daily	60.0	60.0	60.0
Relative Humidity, %			
Monthly Maximum	85.0 (Jun)	-	-
Monthly Maximum	60.0 (Jan)	-	-
Design	75.0 (35°C)	75.0 (35°C)	75.0 (35°C)
Wind			
Velocity, km/hour			
Absolute Maximum	147.0	-	-
Average of Daily Maximum	32.0	28.0	26.0
Design	120.0	120.0	120.0
Direction	SW	NWW	NNE
Atomospheric Pressure, ata	0.968 ± 0.003	1.999 ± 0.003	1.001 ± 0.003
Annual Evaporation, mm	750.0	750.0	750.0

Table V-1 (2) SITE CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT, HIPASAM, ARGENTINE

Items	Project Site Alternatives		
	(PS-1) Sierra Grande, Río Negro	(PS-2) San Antonio Oeste, Río Negro	(PS-3) Bahía Blanca, Buenos Aires
SOIL CONDITION			
General Conditions	Flat (Not Developed)	Flat (Not Developed)	Flat (Developed)
Soil Structure	Silty (0.5-1.0m) Sand Stone (3.0m-)	Silty Sand	Sandy Soil
Soil Bearing Capacity, Ton/m^2			
Surface	20.0	15.0 (Estimate)	15.0 (Estimate)
Ground Rock	100.0 (3.0m)	-	-
Vegetation	None	None	None
Seismic Zone and Coefficient	0.013 (Zone VI: Minor)	0.013 (Zone VI: Minor)	0.013 (Zone VI: Minor)
UTILITY SUPPLY AND PRICE			
Water, Existing	A Pipeline from Arroyo de los Berros and Arroyo de la Ventana: 486m^3/h(120km)	Canal Pomona (37km) from from Río Negro: 1,100m^3/h	DOSBA:
Water, Potential	A Pipeline from Arroyo de los Berros: 79m^3/h(120km)	-	-
Electric Power	AyE: 50 MW, 132 KV, 50 Hz	AyE: 12 MW, US$0.015/kWh 132 KV, 50 Hz	DEBA: 132 KV, 50 Hz
Natural Gas	Gas del Estado: US$0.045/$Nm^3$, 25 atg, 8 Inch Diameter	Gas del Estado: 2.5 MMm^3/day US$0.045/$Nm^3$	Gas del Estado: US$0.045/$Nm^3$
Fuel Oil	Lorry Supply	Lorry Supply	Lorry Supply
Waste Water Treatment	None	Yes: 800m^3/hr	Yes:
INFRASTRUCTURES			
Access Road	Paved Road with 7 meter Width	Paved Road with 7 meter Width	Paved Road with 7 meter Width

Table V-1 (3) SITE CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT PROJECT, HIPASAM, ARGENTINE

Items	Project Site Alternatives		
	(PS-1) Sierra Grande, Río Negro	(PS-2) San Antonio Oeste, Río Negro	(PS-3) Bahía Blanca, Buenos Aires
State High Way Connection	A 3km for Ruta 3	A 38km for Ruta 3, Ruta 251, Ruta 308 and Ruta 23	A 5km for Ruta 3, Ruta 33, Ruta 35 and A 35km for Ruta 22
Rail Road Connection	A 134km for San Antonio Oeste of EFEA	A 25km for San Antonio Oeste of EFEA	A 5km for Bahía Blanca of EFEA
Ocean Port Connection, km			
Punta Colorada (27ft, No Crane)	32.0	166.0	528.0
San Antonio Oeste (40ft, 45 Ton Crane)	134.0	2.0	394.0
Puerto Madryn (30ft, 12 Ton Crane)	144.0	278.0	672.0
Bahía Blanca (36ft, 50 Ton Crane)	528.0	394.0	10.0
Buenos Aires (27ft, 150 Ton Crane)	1,213.0	1,079.0	685.0
Air Port Connection, km	A 208km for Trelew	A 160km for Viedma (Heliport at San Antonio Este)	A 10km for Bahía Blanca
ACCOMMODATIONS			
Community	Sierra Grande	San Antonio Oeste	Bahía Blanca
Population	10,000	9,000	180,000
Hotel	Yes	Yes	Yes
School	Yes	Yes	Yes
Hospital	Yes	Yes	Yes
GroceryYes	Yes	Yes	Yes
Telecommunication	Yes	Yes	Yes
Construction Camp	(Yes)	(None)	(Yes)
INVESTMENT INCENTIVES			
Provincial Incentives			
Equity Participation	Yes	Yes	(None)
Loan Financing	Yes	Yes	(None)
Industrial Park	(None)	(None)	Yes
Utility Supply	Yes	Yes	Yes
Training Subsidy	Yes	Yes	Yes
Housing Subsidy	Yes	Yes	(None)
Research Assistance	Yes	Yes	(Yes)
Local Tax, %	-	-	-
Local Tax Holiday, year	-	-	-

Table V-2 BRIEF DESIGN CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PLANT, ARGENTINE

	Project Site Alternatives		
	PS-1 Sierra Grande, Rio Negro	PS-2 San Antonio Oeste, Rio Negro	PS-3 Bahia Blanca, Buenos Aires
Location			
Longitude, West/ Latitude, South	65°20'/41°30'	64°45'/40°45'	62°15'/38°45'
Height, Meter above Sea Level	268.0	10.0	10.0
Climatic Conditions			
Temperature, °C			
- Maximum	42.0	42.0	42.0
- Minimum	(-)10.0	(-)10.0	(-)10.0
Humidity, %	75.0	75.0	75.0
(Temperature, °C)	(30.0)	(30.0)	(30.0)
Rainfall, mm			
- Daily Maximum	60.0	60.0	60.0
Wind Velocity, km/hour	120.0	120.0	120.0
(Direction)	(SW)	(NWW)	(NNE)
Atmospheric Pressure, ata	0.968 (±)0.003	0.999 (±)0.003	1.001 (±)0.003
Soil Conditions			
Bearing Capacity, Ton/m^2	20.0	15.0 (Estimate)	15.0 (Estimate)
Seismic Coefficient	0.013	0.013	0.013
(Zone, Magnitude)	(VI, Minor)	(VI, Minor)	(VI, Minor)
Utility Supply Conditions			
Raw Water			
- Analysis, ppm			
Total Hardness, $CaCO_3$	125.0	119.0	-
SO_4,	88.0	18.0	-
Cl,	-	23.0	-
pH	-	7.5	-
- Source	Arroyo de los Berros, Arroyo de la Ventana	Canal Pomona from Rio Negro	Pipeline from Rio Colorada
- Supply Location	Battery Limit	Battery Limit	Battery Limit
Electric Power			
- Conditions	132 KV, 50 Hz	132 KV, 50 Hz	132 KV, 50 Hz
- Source	3 Phase, 3 Wire	3 Phase, 3 Wire	3 Phase, 3 Wire
- Supply Location	Aye Battery Limit	Aye Battery Limit	Beba Battery Limit
Natural Gas			
- Heating Value, Cal/Nm^3, LHV/HHV	9,012/9,970	9,012/9,970	9,012/9,990
- Pressure, ata	25.0	25.0	25.0
- Source	Gas del Estado	Gas del Estado	Gas del Estado
- Supply Location	Battery Limit	Battery Limit	Battery Limit

Table V-3 RAW MATERIAL CONDITIONS FOR PHOSPHATE ROCK CONCENTRATION PLANT

1. Source: Non-Magnetic Tails from Magnetic Separator (Between 828/9 to 850) at Iron Ore Concentration Plant, HIPASAM, Sierra Grande, Rio Negro, Argentine

2. Specification:

- Analysis, Dry Weight

Fe	27.53%
Fe (II)	13.78
Fe (III)	13.75
K_2O	0.67
Na_2O	0.23
MgO	1.14
CaO	3.93
Al_2O_3	14.23
P	3.09
P_2O_5	(7.08)
SiO_2	19.29
S	2.28
F	0.23
Cl	0.001
CO_2	0.16

- Size Distribution

(+) 0.2 mm	5.0%
(+) 0.1	15.0
(+) 0.05	35.0
(+) 0.02	55.0
(+) 0.01	70.0
(+) 0.005	75.0
(+) 0.002	82.0
(-) 0.002	18.0

- Conditions

Pressure	1.0 ata
Temperature	10.0°C
Solid Content	4.0%
Water Content	96.0
Specific Gravity	1.03

Table V-4 ANALYSIS OF PHOSPHATE ROCK EXTRACTED FROM IRON ORE CONCENTRATION NON-MAGNETIC TAILS OF HIPASAM, SIERRA GRANDE, ARGENTINE

(1) CHEMICAL ANALYSIS

As Element	Weight Percent	As Oxide	Weight Percent	Equivalency for 100g Sample
P	15.56%	P_2O_5	35.65%	(-) 1.507
C (Carbonate)	0.09	CO_2	0.33	(-) 0.015
F	1.50	F	1.50	(-) 0.079
Cl	0.01	Cl	0.01	(-) 0.0005
OH	-	OH	(3.88)	(-) (0.2285)
S (Total)	-	S and Oxides	-	(-) -
S (Sulfide)	0.48	S	0.48	(-) 0.030
S (Sulfate)	-	SO_3	-	(-) -
Si	1.98	SiO_2	4.24	(-) 0.141
Fe (Total)	5.80	Fe Oxides	7.67	(+) 0.233
Fe (II)	4.36	FeO	(5.61)	(+) (0.156)
Fe (III)	1.44	Fe_2O_3	(2.06)	(+) (0.077)
Al	1.46	Al_2O_3	2.06	(+) 0.162
Mn	-	MnO	-	(+) -
Ca	31.66	CaO	44.30	(+) 1.580
Mg	0.22	MgO	0.36	(+) 0.018
Na	0.15	Na_2O	0.20	(+) 0.006
K	0.07	K_2O	0.08	(+) 0.002
Others	-	Others	-	-
Free Moisture	0.14	Free Moisture	0.14	-
Organics	-	Organics	-	-
Ignition Loss	1.68	Ignition Loss	1.68	
Total	65.95	Sub-total	102.58	(-) 2.001
		Adjustment for F	(-) 0.63	(+) 2.001
		Total	101.95	(+) 0.000

(2) PHYSICAL PROPERTY

Color			Gray
Size Distribution (Tyler Mesh and Millimeter)			
(+) 400	Mesh	(0.0370 mm)	15.9%
(+) 468.4		(0.0316)	18.4
(+) 677.8		(0.0219)	36.1
(+) 993.3		(0.0149)	52.5
(+) 1,309.7		(0.0113)	64.5
(-) 1,309.7		(0.0113)	35.4
			100.0
Density			3.27
Bulk Density	- Packed		1.67
	- Loose		1.27
Angle of Reponse			43.0°
Free Moisture of Filter Cake, %			13.0
Specific Surface Area, cm^2/gr			2,770

(3) FERTILIZER PROPERTY

	Weight Percent	Solubility Percent
Total P_2O_5	35.65%	100.0%
Nitric Acid Soluble P_2O_5	35.60	99.9
Hydrocholoric Acid Soluble P_2O_5	35.11	98.5
Citric Acid Soluble P_2O_5	7.96	22.3
Formic Acid Soluble P_2O_5	5.69	16.0
Ammonium Citrate Soluble (AV) P_2O_5 (Neutral)	0.00	0.0
Water Soluble P_2O_5	0.00	0.0

Notes: - Sample tails (Fe=27.53%, P_2O_5=7.08%) were taken on October 6, 1983 at HIPASAM and concentration test and analysis were made at NIKKO Consulting and Engineering Co. Ltd., Japan in January, 1984. Recovery of P_2O_5 is 55.5%. Fertilizer property was determined at Nissan Chemical Industries, Ltd., Japan in March, 1984.
- Ignition loss is measured by heating at 900°C for 0.5 hours.
- Free moisture is measured by heating at 105°C for 5.0 hours.
- (OH) is estimated to keep balanced equivalency.

Table V-5 FUSED MAGNESIUM PHOSPHATE PRODUCTION TEST FOR PHOSPHATE ROCK EXTRACTED FROM IRON ORE CONCENTRATION NON-MAGNETIC TAILS OF HIPASAM, SIERRA GRANDE, ARGENTINE

	Input		Output
	Raw Material Phosphate Rock	Raw Material Serpentine	Product Fused Magnesium Phosphate
(1) CHEMICAL ANALYSIS			
Total P_2O_5	35.65%	0.10%	20.61%
SO_3	0.46	0.10	-
F	1.33	0.05	0.79
SiO_2	4.24	38.50	21.40
Fe_2O_3	8.29	8.00	8.80
Al_2O_3	2.56	1.40	1.88
CaO	44.30	2.20	27.57
MgO	0.30	35.60	17.89
Ignition Loss	1.68	13.72	0.00
Origin	(Sierra Grande, Río Negro)	(Calamuchita, Córodoba)	-
(2) PHYSICAL PROPERTY			
Color	Dark Green	Gray	Dark Green
Bulk Density			
Loose	1.27	1.50	1.55
Packed	1.67	1.65	1.75
Angle of Reponse			
Dry	43.0°	32.0°	30.0°
Wet	50.0°	45.0°	45.0°
Size Distribution			
+ 1.0mm	0.0%	10.0%	15.0%
+ 0.5, (-) 1.0	0.0	30.0	30.0
+ 0.1, (-) 0.5	0.0	40.0	35.0
+ 0.01, (-) 0.1	65.0	20.0	20.0
Solubility of P_2O_5			
Total P_2O_5	35.65%	0.10%	20.68%
Nitric Acid	35.60	0.10	20.60
Hydrochloric Acid	35.11	0.10	20.30
Citric Acid	7.96	0.00	20.30
Formic Acid	5.69	0.00	9.27
Ammonium Citrate (Neutral)	0.00	0.00	13.40
Water	0.00	0.00	0.00
Citric Acid Solubility			
P_2O_5	7.96%	0.00%	20.30%
MgO	0.00	0.00	15.50
SiO_2	0.00	0.00	20.50
Total Alkalinity	-	-	50.00
Molar Ratio, MgO/SiO_2	-	-	1.25
(3) MATERIAL AND ENERGY BALANCE			
Operating Condition	-	-	1,350°C for 0.05hr
Phosphate Rock, Ton	0.580	-	-
Sepentine, Ton	-	0.498	-
Fused Magnesium Phosphate, Ton	-	-	1.00
Waste Water, m^3			3.00; F=15 ppm
Flue Gas, Nm^3			3,000; F=50 ppm
Natural Gas, MMBTU-LHV	5.67		
For Open Hearth Furnance	(5.10)		
For Product Dryer	(0.57)		
Electric Plwer, kWh	130.0		
Industrial Water Circulation, m^3	40.0		
Industrial Water Makeup, m^3	4.0		
Brick for Repair, Ton	0.01		
Lime for Neutratization, Ton	0.02		

Notes;
- Small scale tests (Phosphate Rock: 0.5 kg/Batch) carried out at Hinode Kagaku K.K., Japan in March, 1984.
- The raw material mixture is ideal for fused magnesium phosphate production at open hearth furnace, the melting and quenching properties are almost identical to the actual operation at the commercial operation at Hinode Kagaku K.K.

Table V-6 WET PROCESS PHOSPHORIC ACID PRODUCTION TEST FOR PHOSPHATE ROCK EXTRACTED FROM IRON ORE CONCENTRATION NON-MAGNETIC TAILS OF HIPASAM, SIERRA GRANDE, ARGENTINE (1)

	Input	Output	
	Raw Material Phosphate Rock	Product Phosphoric Acid (Filter Acid)	By-Product Gypsum
(1) CHEMICAL ANALYSIS			
Total P_2O_5	35.65%	30.00%	0.64%
H_3PO_4	(49.21)	(41.41)	(0.88)
Water Soluble P_2O_5	0.00	30.00	0.10
SO_3	-	4.08	45.40
F	1.50	0.63	0.43
SiO_2	4.24	0.25	2.74
Fe_2O_3	8.29	6.84	0.12
Al_2O_3	2.56	2.02	0.11
CaO	44.30	0.08	31.80
MgO	0.30	0.24	0.02
Na_2O	0.16	0.08	0.05
K_2O	0.06	0.04	0.01
(2) PHYSICAL PROPERTY			
Color	Gray	Pale Gray	White
Bulk Density	1.27 (Loose)	1.50 (25°C)	1.30
	1.67 (Packed)	1.48 (50)	-
		1.46 (75)	-
Angle of Reponse	43.0°	0.00°	60.0°
Viscosity, CP	-	20.80 (25°C)	-
	-	9.80(50)	-
	-	5.50(75)	-
Free Moisture	0.14%	43.77%	24.0%
Specific Surface Area, cm^2/g	-	-	2,770
Average Crystal Size, mm	0.028	-	0.20 x 0.03 x 0.01
(3) MATERIAL AND ENERGY BALANCE			
	-Phosphate Rock 2.88 Ton	-Filter Acid 3.333 Ton	-Wet Gypsum 5.333 Ton
	-Sulfuric Acid 2.34 Ton	(P_2O_5: 1.00 Ton)	-Waste Water 0.15 m^3 (F 0.60%)
	-Electric Power 80.00 kWh		-Effluent Gas 3,500 Nm^3 (F 0.10 g/Nm^3)
	-Steam 0.08 Ton		
	-Process Water 5.5 m^3		
	-Lime for Neutralization 0.02 Ton		

Notes:
- Small scale tests (Phosphate Rock: 0.4 kg/Batch) by appling hemihydrate-dihydrate wet process phosphoric acid process were carried out at Nissan Chemical Industries, Ltd., Japan in March, 1984. Recovery of P_2O_5 is expected 97.5%
- Decomposition by mixed acid (P_2O_5 30%, SO_3 4.08%) at 85 to 95°C for 0.5 hours, hydration at 55 to 60°C for 7.5 hours by adding seed gypsum with solid content at 30 to 32% and filteration at 50 to 55°C under (-) 0.592 ata vacuum and two stage washings at 57 mm of cake thickness were applied. (Filter rate: 5.0 Ton of $P_2O_5/m^2 \cdot day$).
- All Fe is expressed in terms of Fe_2O_3 as simplicity.

Table V-6 (1) WET PROCESS PHOSPHORIC ACID PRODUCTION TEST FOR PHOSPHATE ROCK EXTRACTED FROM IRON ORE CONCENTRATION NON-MAGNETIC TAILS OF HIPASAM, SIERRA GRANDE, ARGENTINE (2)

	Test Conditions					
	Sulfuric Acid Decomposition (Hemi hydrate Gypsum)		Hydration (Di hydrate Gypsum)		Filteration (Di hydrate Gypsum)	
(1) Feed Condition	-Phosphate Rock: 35.65% P_2O_5		-Decomposition Slurry		-Hydration Slurry	
	-Sulfuric Acid: 75.00% H_2SO_4					
	-Mixed Acid: 30.00% P_2O_5		-Gypsum Seed		-Washing	
	(Simulated for Phosphae Rock) 4.08% SO_3				-Water	
					-Weak Acid: 5.0% P_2O_5	
Temperature, °C	85-95		55-60		55-60	
Pressure, ata	1.0		1.0		(-) 0.592	
Duration, hr	0.5		10.0		5.0 Ton of P_2O_5/m^2.day	
(2) Performance	Decomposition	Hydration	Decomposition	Hydration	Decomposition	Hydration
0.00 hr	0.0%	0.0%	-	-	-	-
0.25	62.5	0.0	-	-	-	-
0.33	72.3	0.0	-	-	-	-
0.50	79.1	0.62	79.1%	0.62%	-	-
1.50	-	-	91.9	1.72	-	-
3.50	-	-	95.9	1.90	-	-
5.50	-	-	97.6	1.97	-	-
10.50	-	-	98.2	1.95	-	-
(3) P_2O_5 Recovery	-	-	-	-	97.1	1.95
(4) Filteration Yield						
- First stage	-	-	-	-	-	48.0%
- Second stage	-	-	-	-	-	30.0
- Third stage	-	-	-	-	-	24.0
(5) Filter Cake Tickness	-	-	-	-	-	57.0 mm
(6) Gypsum Crystalline Size, mm	-	-	-	-	-	0.20 x 0.03 x 0.01
(7) Gypsum Specific Surface Area, cm^2/g	-	-	-	-	-	2,770

Table V-7 PROJECT SITE ALTERNATIVES SELECTION FOR PHOSPHATE FERTILIZER PLANT BY RAW MATERIALS AND PRODUCT TRANSPORT REQUIREMENTS

(Unit. Ton-km/Ton of Product Phosphate Fertilizer)

Phosphate Fertilizer Product Alternatives		Tonnage (Ton/Ton)	Project Site Alternatives: PS-1 Sierra Grande, Rio Negro — Raw Materials (SAO/SG-SG) (km)	PS-1 Product[4] (SG-BB) (km)	PS-2 San Antonio Oeste, Rio Negro — Raw Materials (SAO/SG-SAO) (km)	PS-2 Product[4] (SAO-BB) (km)	PS-3 Bahia Balnca, Buenos Aires — Raw Materials (BB/SG-BB) (km)	PS-3 Product[4] (BB-BB) (km)
PF-1, GGPR	Granular Ground Phosphate Rock							
	Raw Materials							
	- Phosphate Rock	0.9692	0.0	-	134.0	-	528.0	-
	- Potassium Chloride	0.0515	134.0	-	0.0	-	0.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product			534.9		523.9		511.7
PF-2, FMP	Fused Magnesium Phosphate							
	Raw Materials							
	- Phosphate Rock	0.5917	0.0	-	134.0	-	528.0	-
	- Serpentine[1]	0.5080	1,504.0	-	1,370.0	-	976.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product			1,292.0		1,169.2		808.2
PF-3, SSP	Single Super Phosphate							
	Raw Materials							
	- Phosphate Rock	0.5886	0.0	-	134.0	-	528.0	-
	- Sulfur	0.1154	134.0	-	0.0	-	0.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product			543.5		472.9		310.8
PF-4, TSP	Triple Super Phosphate							
	Raw Materials							
	- Phosphate Rock	1.3839	0.0	-	134.0	-	528.0	-
	- Sulfur	0.2602	134.0	-	0.0	-	0.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product			562.9		579.4		730.7
PF-5, MAP	Monoammonium Phosphate							
	Raw Materials							
	- Liquid Ammonia[2]	0.1279x2.5	134.0	-	0.0	-	0.0	-
	- Phosphate Rock	1.3687	0.0	-	134.0	-	528.0	-
	- Sulfur	0.3698	134.0	-	0.0	-	0.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product[3]			620.4		577.4		722.8
PF-6, NP/CAN	Nitrophosphate/Calcium Ammonium Nitrate							
	Raw Materials							
	- Liquid Ammonia[2]	0.2996x2.5	134.0	-	0.0	-	0.0	-
	- Phosphate Rock	0.3296	0.0	-	134.0	-	528.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product			628.4		438.2		174.0
PF-7, NP/CAN	Nitrophosphate/Calium Ammonium Nitrate							
	Raw Materials							
	- Phosphate Rock	0.3296	0.0	-	134.0	-	528.0	-
	Product	1.0000	-	528.0	-	394.0	-	0.0
	Ton-km/Ton-Product			528.0		438.2		174.0

Notes:
1) Serpentine is assumed to be supplied from Corboda.
2) Liquid ammonia transport is weighted by 2.5 factor due to costly handling of high pressure and inflamable liquid.
3) In case the PF-5, MAP project is split into two projects; the sulfuric and phosphoric acid plants are located in PS-1 and the monoammonium phosphate plant only is located in PS-1, PS-2 or PS-3, the ton-km/ton-product for PS-1, PS-2 and PS-3 are 620.4, 552.4 and 624.3, respectively, because 1.1823 ton of phosphoric acid (P_2O_5; 40.0%) will be transported between PS-1 to PS-2 or PS-3.
4) The weighted average destination of phosphate fertilizer consumption is located in a little north-west of Bahia Blanca, therefore the product transport requirements are assumed upto Bahia Blanca for the site selection calculation.

Table V-8 ALTERNATIVES OF PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

Product	Daily Production	Production Specification, %: T-N	A-N	N-N	T-P_2O_5	Av-P_2O_5	C-P_2O_5	F-P_2O_5	W-P_2O_5	W-K_2O	Free Moisture	Free Acid	Other Major Raw Material and Utility Daily Consumption	
	TPD													
PF-1, GGPR, Granular, Bagged	347.4	0.0	0.0	0.0	33.87 (24.0)	0.0	7.60	5.40 (14.4)	0.0	3.00	0.70 (4.0)	0.0	MOP	17.9 TPD
PF-2, FMP, Sandy, Bagged	569.0	0.0	0.0	0.0	20.68	13.40	20.30 (11.9) for Escorias Thomas	9.27	0.0	0.0	0.30	0.0	Serpentine	289.1 TPD
PF-3, SSP, Granular, Bagged	572.0	0.0	0.0	0.0	20.57 (19.5)	16.04	-	-	10.70 (18.0)	0.0	3.00 (4.0)	4.0 (3.7)	Sulfur	66.0 TPD
PF-4, TSP, Granular, Bagged	243.3	0.0	0.0	0.0	47.33 (45.0)	35.50	-	-	31.00 (40.0)	0.0	3.0 (4.0)	7.0 (4.0)	Sulfur	63.3 TPD
PF-5, MAP, Granular, Bagged	243.8	10.20 (11.4)	10.20	0.0	46.80	45.91 (48.0)	-	-	30.42	0.0	0.9	0.0	Ammonia, Sulfur	31.2 TPD 90.2 TPD
PF-6, NP, ' Granular, Bagged	551.1	20.80 (20.0)	11.40	9.40	21.10	20.80 (19.0)	-	-	15.83	0.0	0.60	0.0	Ammonia,	306.0 TPD
/CAN, Granular, Bagged	470.4	26.00 (20.50)	13.00	13.00	0.0	0.0	-	-	0.0	0.0	0.40	0.0	Natural Gas	2,788 MMBTU -LHV/D
Averaged Total	1,021.5	23.19	12.14	11.05	11.38	11.22	-	-	8.54	0.0	0.51	0.0		
PF-7, NP, Granular, Bagged	551.1	20.80 (20.0)	11.40	9.40	21.10	20.80 (19.0)	-	-	15.83	0.0	0.60	0.0	Natural Gas	10,025 MMBTU -LHV/D
/CAN, Granular, Bagged	470.4	26.00 (20.50)	13.00	13.00	0.0	0.0	0.0	-	0.0	0.0	0.40	0.0		
Averaged Total	1,021.5	23.19	12.14	11.05	11.38	11.22	-	-	8.54	0.0	0.51	0.0		

Notes: 1) Production is designed to consume 336.7 TPD (100,000 TPY/297 DPY) of phosphate rock (P_2O_5; 35.65%, Fe; 5.8%) which is recovered from non-magnetic tails at phosphate rock concentration plant, Sierra Grande, Argentine.

2) Requirement at fertilizer control order in Argentine (IRAM) is referred by underlined analysis and its figure is indicated in parenthesis.

Table V-9 PROJECT ALTERNATIVES FOR PHOSPHATE ROCK CONCENTRATION AND PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

Project	Plant and Product	Site	Daily Production and P_2O_5 Efficiency			Annual Production			
		Location	Material	Total P_2O_5	Effective P_2O_5	Material	N	Effective P_2O_5	K_2O
			TPD	TPD (Efficiency, %)	TPD (Efficiency, %)	TPY	TPY	TPY	TPY
Phosphate Rock Concentration Plant									
PC-1, PR	Phosphate Rock Concentration, Bulk	PS-1, Sierra Grande	336.7	120.0 (100.0)	F-P_2O_5; 19.2 (16.0)	100,000	0.0	,5,690.0	0.0
Phosphate Fertilizer Plant									
PF-1, GGPR	Granular Ground Phosphate Rock, Bagged	PS-3, Bahia Blanca	347.4	117.7 (98.1)	F-P_2O_5; 18.8 (15.6)	103,178	0.0	5,571.6	3,095.3
PF-2, FMP	Fused Magnesium Phosphate, Bagged	PS-3, Bahia Blanca	569.0	117.7 (98.1)	C-P_2O_5; 115.5 (96.3)	168,993	0.0	34,305.5	0.0
PF-3, SSP	Single Super Phosphate, Bagged	PS-3, Bahia Blanca	572.0	117.7 (98.1)	W-P_2O_5; 61.2 (51.0)	169,884	0.0	18,177.6	0.0
					T-P_2O_5; 117.7 (98.1)			34,945.1	
PF-4, TSP	Triple Super Phosphate, Bagged	PS-1, Sierra Grande	243.3	115.2 (96.0)	W-P_2O_5; 75.4 (62.9)	72,260	0.0	22,400.6	0.0
					T-P_2O_5; 115.2 (96.0)			34,200.7	
PF-5, MAP	Monoammonium Phosphate, Bagged	PS-3, Bahia Blanca	243.8	114.1 (95.1)	Av-P_2O_5; 111.9 (93.3)	72,409	7,385.7	33,242.8	0.0
PF-6, NP/CAN	Nitrophosphate and Calcium Ammonium Nitrate by Ammonia Import	PS-3, Bahia Blanca	1,021.5	116.2 (96.8)	Av-P_2O_5; 114.6 (95.5)	303,386	70,355.1	34,039.9	0.0
PF-7, NP/CAN	Nitrophosphate and Calcium Ammonium Nitrate by Ammonia Production	PS-3, Bahia Blanca	1,021.5	116.2 (96.8)	Av-P_2O_5; 114.6 (95.5)	303,386	70,355.1	34,039.9	0.0

Table V-10 BASIS FOR FINANCIAL ANALYSIS OF PHOSPHATE FERTILIZER PRODUCTION

Product and Production			Consumption/Ton of Product, Bagged									
Product	Product Sepcification (Fertilizer Nutrients, %) N - P_2O_5 - K_2O	Daily Production (TPD)	Liquid Ammonia	Phos-phate Rock	Potassium Chloride	Sulfur	Ser-pentine	Natural Gas (MMBTU-LHV)	Electric Power (kWh)	Raw Water	Chemicals and Catalysts (USD)	Fertilizer Bag, (Sheet)
PF-1, GGPR	0.0 -33.87(5.40)-3.0 T- F- W-	347.4	-	0.9692	0.0515	-	-	0.555	55.50	0.25	-	20.20
PF-2, FMP	0.0 -20.30 -0.0 C-	569.0	-	0.5917	-	-	0.5080	6.050	155.50	5.60	1.250	20.20
PF-3, SSP	0.0 -20.57(10.70)-0.0 T- W-	572.0	-	0.5086	-	0.1154	-	-	69.23	4.40	0.275	20.20
PF-4, TSP	0.0 -47.33(31.00)-0.0 T- W-	243.3	-	1.3839	-	0.2602	-	-	139.74	7.37	0.271	20.20
PF-5, MAP	10.2 -45.91 -0.0 T- Av-	243.8	0.1279	1.3687	-	0.3698	-	-	180.49	7.38	0.373	20.20
PF-6, NP/ CAN	20.80-20.80 -0.0 26.00- 0.0 -0.0 23.19-11.20 -0.0 T- Av-	551.1 470.4 1,021.5	0.2996	0.3296	-	-	-	2.730	171.1	5.47	0.984	20.20
PF-7, NP/ CAN	20.80-20.80 -0.0 26.00- 0.0 -0.0 23.19-11.20 -0.0 T- Av-	551.1 470.4 1,021.5	-	0.3296	-	-	-	9.815	419.7	7.06	1.525	20.20

Table V-11 EVALUATION AND SELECTION OF ALTERNATIVES FOR PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE

Alternatives	Evaluation and Selection Items and Criteria								Overall Evaluation
	Raw Materials Availability in Argentine, Foreign Currency Saving	Utility Consumption (Low)	Product P_2O_5 Evaluation in Argentine (IRAM)	Product P_2O_5 Water Solubility (High)	Product Physical Property	Product Market Development	Phosphate Rock Applicability to Conventional Production Process	Plant Investment Costs (Low)	
PF-1, GGPR	B	A	D (Formic)	D	A	C	A	A	C
PF-2, FMP	A	B	A (Citric)	D	B	D	A	A	B
PF-3, SSP	C	A	C (Total/Water)	C	C	C	C	A	C
PF-4, TSP	C	A	C (Total/Water)	C	C	B	C	B	B
PF-5, MAP	D	A	B (Citrate)	B	A	A	B	B	A
PF-6, NP/CAN -Ammonia Import	D	B	A (Citrate)	A	A	A	A	C	B
PF-7, NP/CAN -Ammonia Production	A	B	A (Citrate)	A	A	A	A	C	A

Table V-12 ORGANIZATION AND PERSONNEL REQUIREMENTS

Feasibility Study: On the Establishment of a Phosphate Fertilizer Plant in the Argentine Republic
Project: Phosphate Rock Concentration Plant, and Phosphate Fertilizer Plant, PC-1/PF-5
Product: Monoammonium Phosphate (MAP), Bagged
Capacity: 72,409 TPY of MAP
Location: Sierra Grane, Rio Negro, and Bahia Blanca, Buenos Aires, Argentine

	Organization for the Project	Managing Director, Director	General Manager, Manager	Senior Engineer and Officer	Supervisor, Foreman, Officer	Operator, Worker, Secretary	Total
1.	Head Office and Regional Sales Office - Buenos Aires	(6)	(2)	(3)	(4)	(4)	(19)
2.	Factory Head Office and Plant Factory Complex - Sierra Grande and Bahia Blanca	(2)	(29)	(56)	(127)	(284)	(498)
2.1	Factory Director's Office	(2)	(2)	(4)	(8)	(8)	(24)
2.2	General Affair Department	(0)	(4)	(14)	(14)	(21)	(53)
	- Administration Section	0	1	2	2	3	8
	- Personnel Section	0	0	2	2	3	7
	- Financing/Accounting Section	0	1	2	2	3	8
	- Housing and Welfare Section	0	0	2	2	3	7
	- Security and Health Section	0	1	2	2	3	8
	- Leagal Section	0	0	2	2	3	7
	- Purchase and Product Sales Section	0	1	2	2	3	7
2.3	Production Department	(0)	(6)	(6)	(30)	(108)	(150)
	- Phosphate Rock Concentration Plant	0	3	3	15	64	85
	- Monoammonium Phosphate Fertilizer Plant	0	3	3	15	44	65
2.4	Utility Department	(0)	(4)	(5)	(22)	(40)	(71)
	- Sierra Grande	0	1	2	10	16	29
	- Bahia Blanca	0	3	3	12	24	42
2.5	Maintenance and Inspection Department	(0)	(5)	(11)	(26)	(29)	(70)
	- Maintenance Management	0	1	2	3	3	16
	- Mechanical Section	0	1	2	6	8	36
	- Electrical Section	0	1	2	6	6	29
	- Instrumental Section	0	1	2	5	5	19
	- Civil Construction Section	0	0	1	2	3	9
	- Inventory Section	0	1	2	4	3	15
2.6	Product Handling Department	(0)	(3)	(6)	(9)	(44)	(62)
	- Sierra Grande	0	1	1	4	94	20
	- Bahia Blanca	0	2	5	5	30	42
2.7	Technical and Development Department	(0)	(5)	(10)	(18)	(35)	(68)
	- Production Management	0	2	2	4	4	12
	- Development and Engineering Section	0	2	2	4	4	11
	- Analytical Laboratory	0	1	2	4	20	27
	- Training Section	0	1	2	3	3	9
	- Product Sales Services	0	1	2	3	2	[illegible]
3.	Total Personnel for the Project	8	31	59	131	298	517

Notes: 1) Additional contract laborers for phosphate rock loading and transportation, and product bagging and loading is assumed.

2) During annual maintenance work for 35 days, additional maintenance supervisor and labor are contracted (Vendor specialist; 18, Inspector; 27, Laborer; 250, Total; 295 persons) whose costs are included in maintenance cost for financial analysis.

Table V-13 PROJECT INVESTMENT COST ESTIMATE

Feasibility Study: On the Establishment of a Phosphate Fertilizer Plant in Argentine Republic
Project: Phosphate Rock Concentration Plant and Phosphate Fertilizer, PC-1/PF-5
Product: Monoammonium Phosphate (MAP), Bagged
Capacity: 72,409 TPY of MAP
Location: Sierra Grande, Rio Negro and Bahia Blanca, Buenos Aires, Argentine

		Project Investment Cost Estimate (USD, Million)		
		Foreign Currency Component	Local Currency Component	Total
1.	Land Acquisition	0.00	1.18	1.18
2.	Site Preparation	0.00	0.70	0.70
3.	Plant Direct Cost	25.95	35.97	61.92
3.1	Equipment and Materials, FOB	18.04	9.62	27.66
	(1) Phosphate Rock Concentration Plant	4.10	4.09	8.19
	(2) Monoammonium Phosphate Fertilizer Plant	13.94	5.53	19.47
3.2	Spare Parts, FOB	1.76	0.35	2.11
3.3	Catalysts and Chemicals, FOB	2.40	0.40	2.80
3.4	Civil Materials, CIF	2.05	13.62	15.67
3.5	Construction and Erection Labor	1.70	11.98	13.68
4.	Construction and Erection Equipments	0.35	1.35	1.70
5.	Freight, Insurance & Local Handling	3.76	1.32	5.08
5.1	Ocean Transport	3.31	0.00	3.31
5.2	Unloading and Inland Transport	0.00	0.82	0.82
5.3	Tax, Duty, and Insurance	0.45	0.50	0.95
6.	Indirect Field Expenses	0.20	0.58	0.78
7.	Engineering Services	4.79	0.92	5.71
7.1	General Contractor's Fee	3.06	0.45	3.51
7.2	Supervision and Service Man	1.73	0.47	2.20
8.	Project Management Services	2.15	0.87	3.02
8.1	Construction and Erection Advisor	1.80	0.57	2.37
8.2	Operation and Maintenance Advisor	0.35	0.30	0.65
9.	Base Project Cost, BPC (Without Taxes) -1983	37.20	42.89	80.09

Table V-14 ORGANIZATION AND PERSONNEL REQUIREMENTS

Feasibility Study: On the Establishment of a Phosphate Fertilizer Plant in the Argentine Republic
Project: Phosphate Rock Concentration Plant, and Phosphate Fertilizer Plant, PC-1/PF-7
Product: Nitrophosphate and Calcium Ammonium Nitrate (NP/CAN), Bagged
Capacity: 303,386 TPY of NP/CAN
Location: Sierra Grane, Rio Negro, and Bahia Blanca, Buenos Aires, Argentine

	Organization for the Project	Managing Director, Director	General Manager, Manager	Senior Engineer and Officer	Supervisor, Foreman, Officer	Operator, Worker, Secretary	Total
1.	Head Office and Regional Sales Office - Buenos Aires	(6)	(2)	(3)	(4)	(4)	(19)
2.	Factory Head Office and Plant Factory Complex - Sierra Grande and Bahia Blanca	(2)	(33)	(60)	(147)	(398)	(640)
2.1	Factory Director's Office	(2)	(2)	(4)	(8)	(8)	(24)
2.2	General Affair Department	(0)	(4)	(16)	(16)	(23)	(59)
	- Administration Section	0	1	2	2	3	8
	- Personnel Section	0	0	2	2	3	7
	- Financing/Accounting Section	0	1	2	2	3	8
	- Housing and Welfare Section	0	0	4	2	3	7
	- Security and Health Section	0	1	2	2	3	8
	- Leagal Section	0	1	2	2	3	7
	- Purchase and Product Sales Section	0	0	4	4	5	14
2.3	Production Department	(0)	(7)	(8)	(31)	(132)	(178)
	- Phosphate Rock Concentration Plant	0	3	3	15	64	85
	- Nitrophosphate and Calcium Plant Ammonium Nitrate	0	4	5	16	68	93
2.4	Utility Department	(0)	(4)	(6)	(26)	(48)	(84)
	- Sierra Grande	0	1	2	10	16	29
	- Bahia Blanca	0	3	4	16	32	55
2.5	Maintenance and Inspection Department	(0)	(7)	(11)	(36)	(46)	(100)
	- Maintenance Management	0	2	2	5	5	14
	- Mechanical Section	0	2	2	9	20	33
	- Electrical Section	0	1	2	9	10	22
	- Instrumental Section	0	1	2	5	5	13
	- Civil Construction Section	0	0	1	3	3	7
	- Inventory Section	0	1	2	5	3	11
2.6	Product Handling Department	(0)	(4)	(5)	(12)	(106)	(127)
	- Sierra Grande	0	1	1	4	14	20
	- Bahia Blanca	0	3	5	8	92	107
2.7	Technical and Development Department	(0)	(5)	(10)	(18)	(35)	(68)
	- Production Management	0	2	2	4	4	12
	- Development and Engineering Section	0	2	2	4	4	11
	- Analytical Laboratory	0	1	2	4	20	27
	- Training Section	0	1	2	3	3	9
	- Product Sales Services	0	0	2	3	4	9
3.	Total Personnel for the Project	8	35	63	151	402	659

Notes: 1) Additional contract laborers for phosphate rock loading and transportation, and product bagging and loading is assumed.

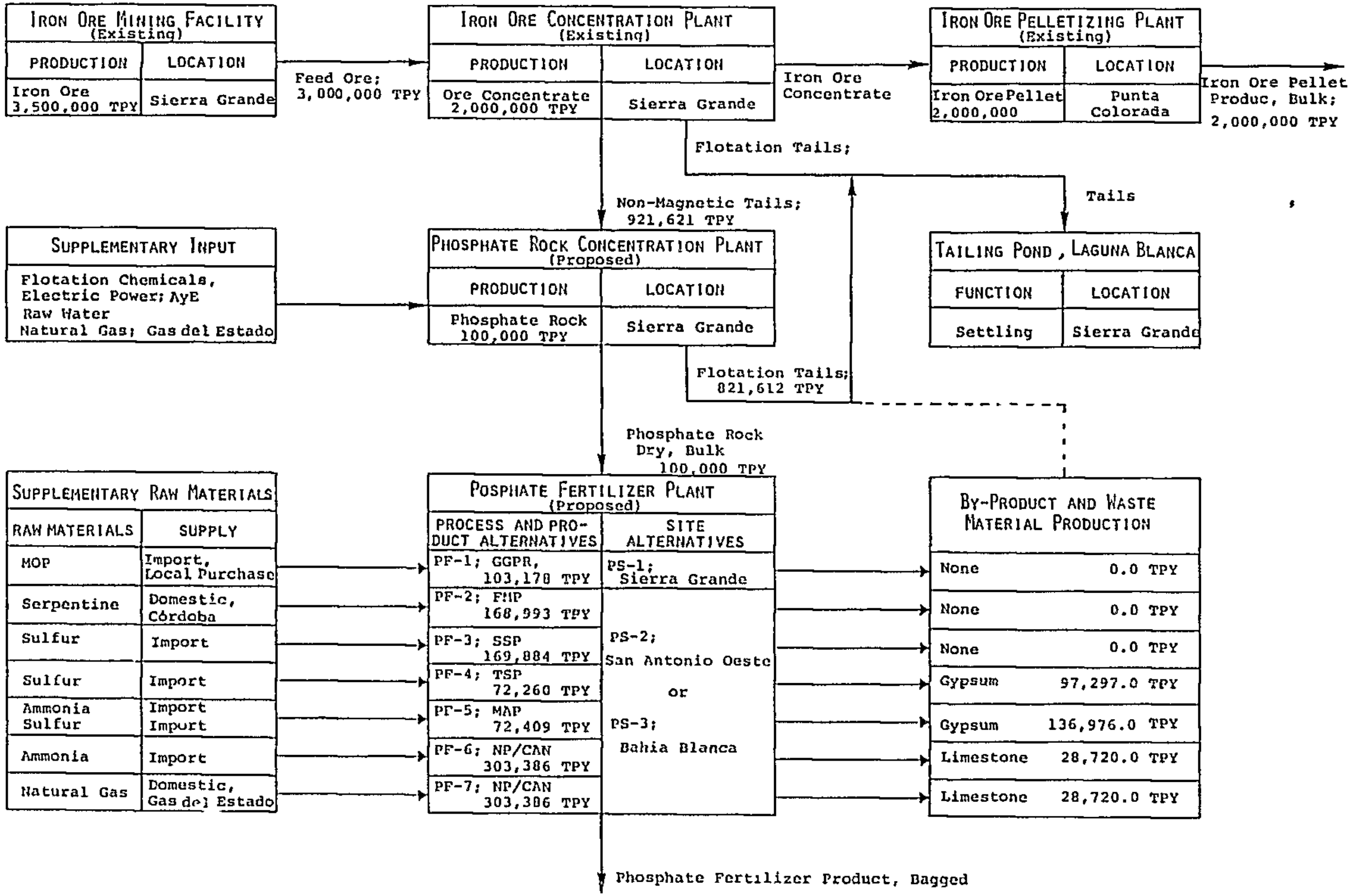
2) During annual maintenance work for 35 days, additional maintenance supervisor and labor are contracted (Vendor specialist; 48, Inspector; 62, Laborer; 550, Total; 660 persons) whose costs are included in maintenance cost for financial analysis.

Table V-15 PROJECT INVESTMENT COST ESTIMATE

Feasibility Study: On the Establishment of a Phosphate Fertilizer Plant in Argentine Republic
Project: Phosphate Rock Concentration Plant and Phosphate Fertilizer, PC-1/PF-7
Product: Nitrophosphate and Calcium Ammonium Nitrate (NP/CAN), Bagged
Capacity: 303,386 TPY of NP/CAN
Location: Sierra Grande, Rio Negro and Bahia Blanca, Buenos Aires, Argentine

		Project Investment Cost Estimate (USD, Million)		
		Foreign Currency Component	Local Currency Component	Total
1.	Land Acquisition	0.00	1. 5	1.15
2.	Site Preparation	0.00	0.90	0.90
3.	Plant Direct Cost	77.51	83.65	161.16
3.1	Equipment and Materials, FOB	58.22	22.05	80.27
	(1) Phosphate Rock Concentration Plant	4.10	4.09	8.19
	(2) Nitrophosphate and Calcium Ammonium Nitrate Plant	54.12	17.96	72.08
3.2	Spare Parts, FOB	4.74	0.35	5.09
3.3	Catalysts and Chemicals, FOB	3.60	0.40	4.00
3.4	Civil Materials, CIF	6.75	35.47	42.22
3.5	Construction and Erection Labor	4.20	25.38	29.58
4.	Construction and Erection Equipments	1.40	4.50	5.90
5.	Freight, Insurance & Local Handling	10.42	3.65	14.07
5.1	Ocean Transport	9.16	0.00	9.16
5.2	Unloading and Inland Transport	0.00	2.39	2.39
5.3	Tax, Duty, and Insurance	1.26	1.26	2.52
6.	Indirect Field Expenses	0.35	1.55	1.90
7.	Engineering Services	19.09	4.19	23.28
7.1	General Contractor's Fee	12.85	1.40	14.25
7.2	Supervision and Service Man	56.24	2.79	9.03
8.	Project Management Services	3.93	1.59	5.52
8.1	Construction and Erection Advisor	2.75	0.97	3.72
8.2	Operation and Maintenance Advisor	1.18	0.62	1.80
9.	Base Project Cost, BPC (Without Taxes) -1983	112.70	101.58	214.28

Figure V-1 OVERALL FLOW SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION IN ARGENTINE



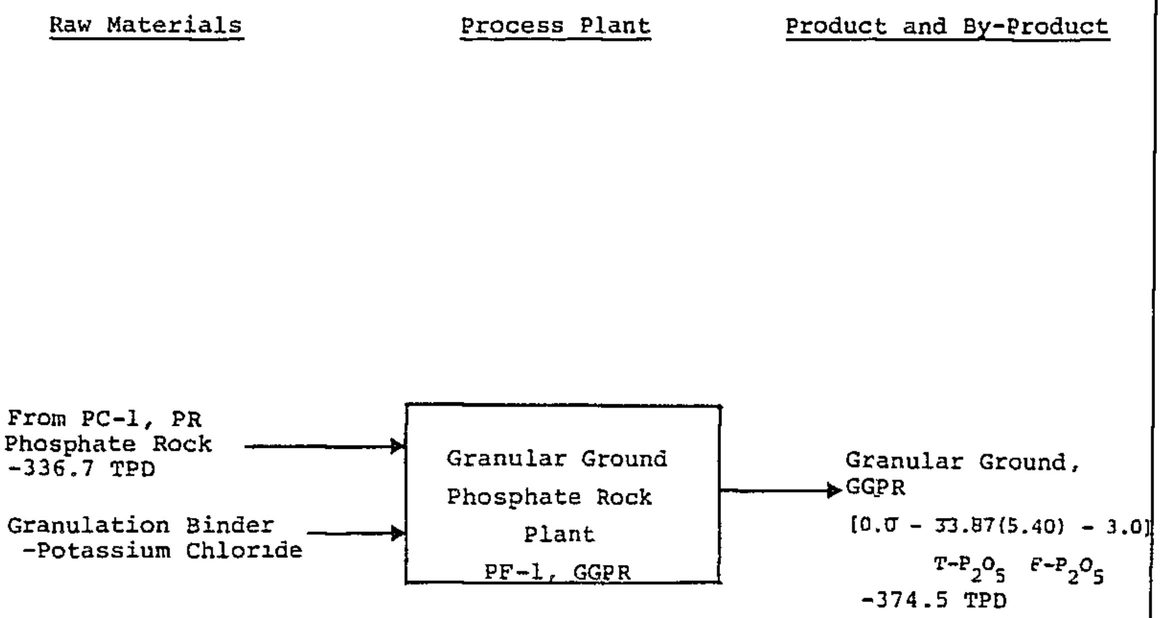


Figure V-2 (1) PROCESS SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION - GRANULAR GROUND PHOSPHATE ROCK

Phosphate Fertilizer Project, Argentine

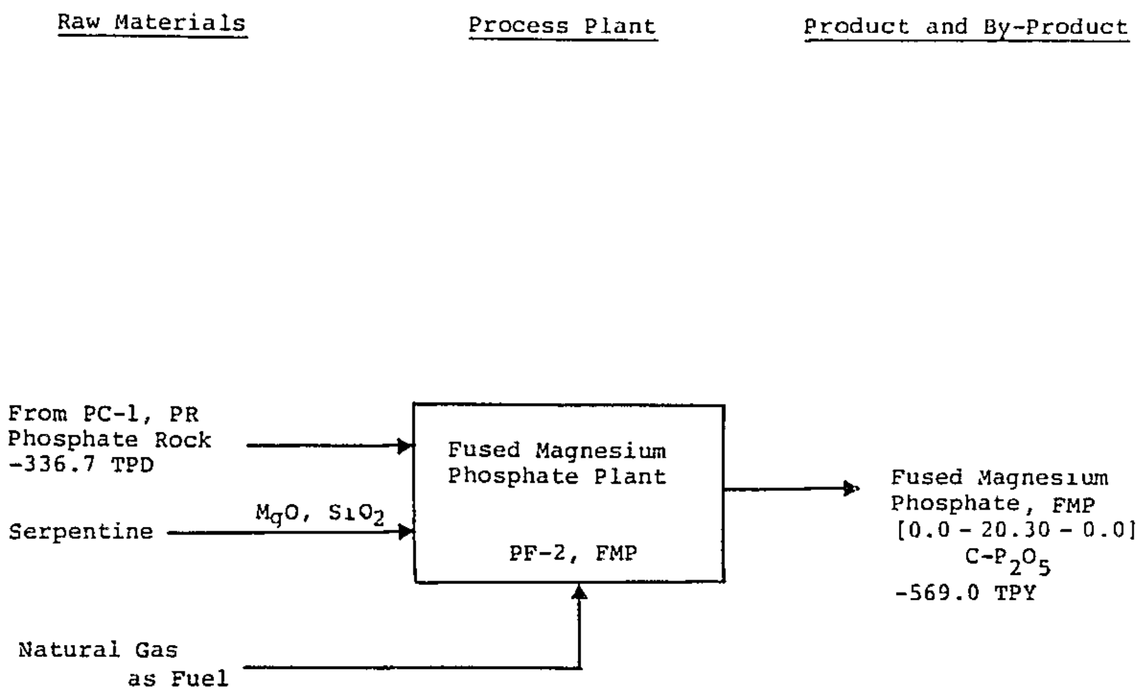


Figure V-2 (2) PROCESS SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION - FUSED MAGNESIUM PHOSPHATE

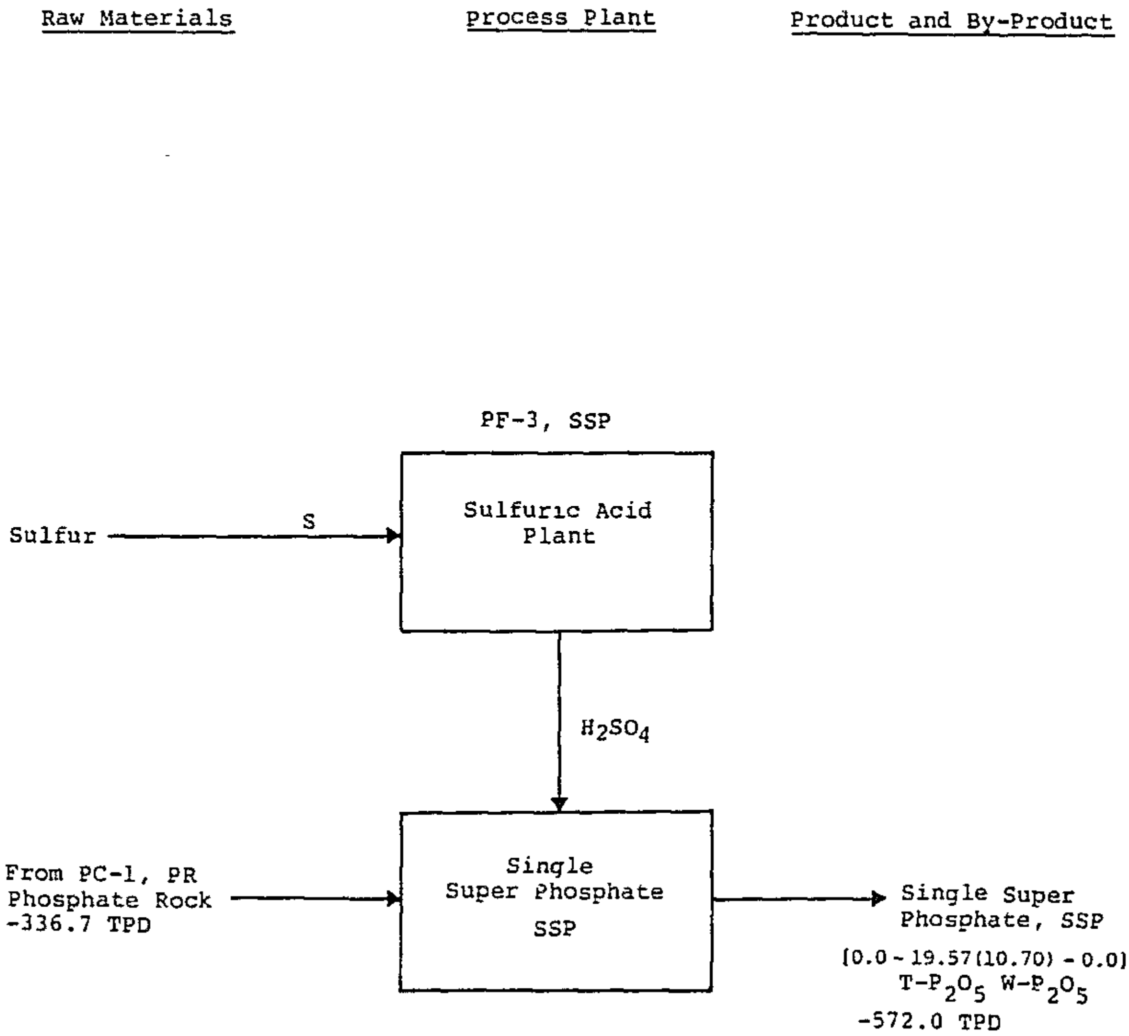


Figure V-2 (3) PROCESS SHCEME FOR PHOSPHATE FERTILIZER PRODUCTION - SINGLE SUPER PHOSPHATE

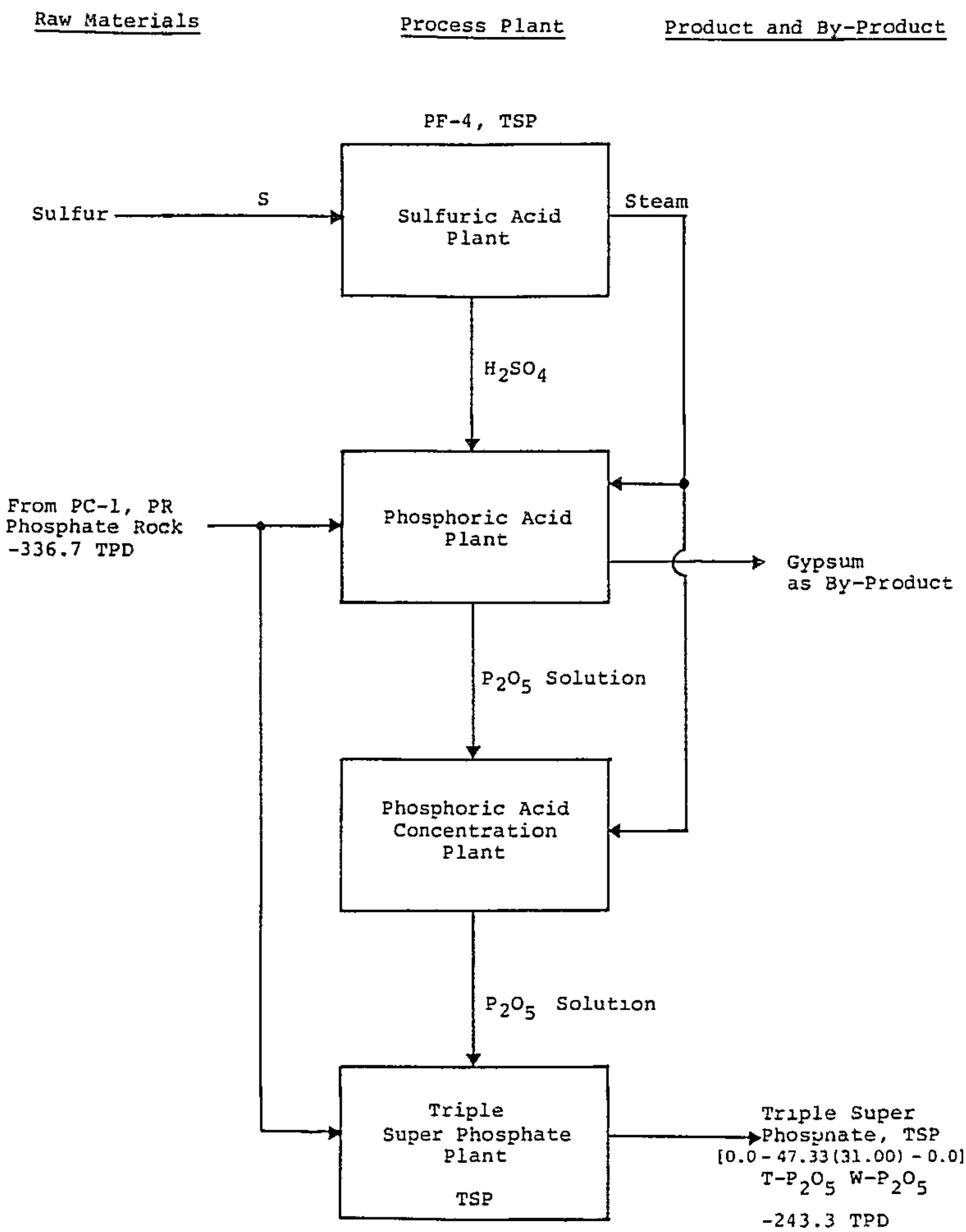


Figure V-2 (4) PROCESS SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION - TRIPLE SUPERPHOSPHATE

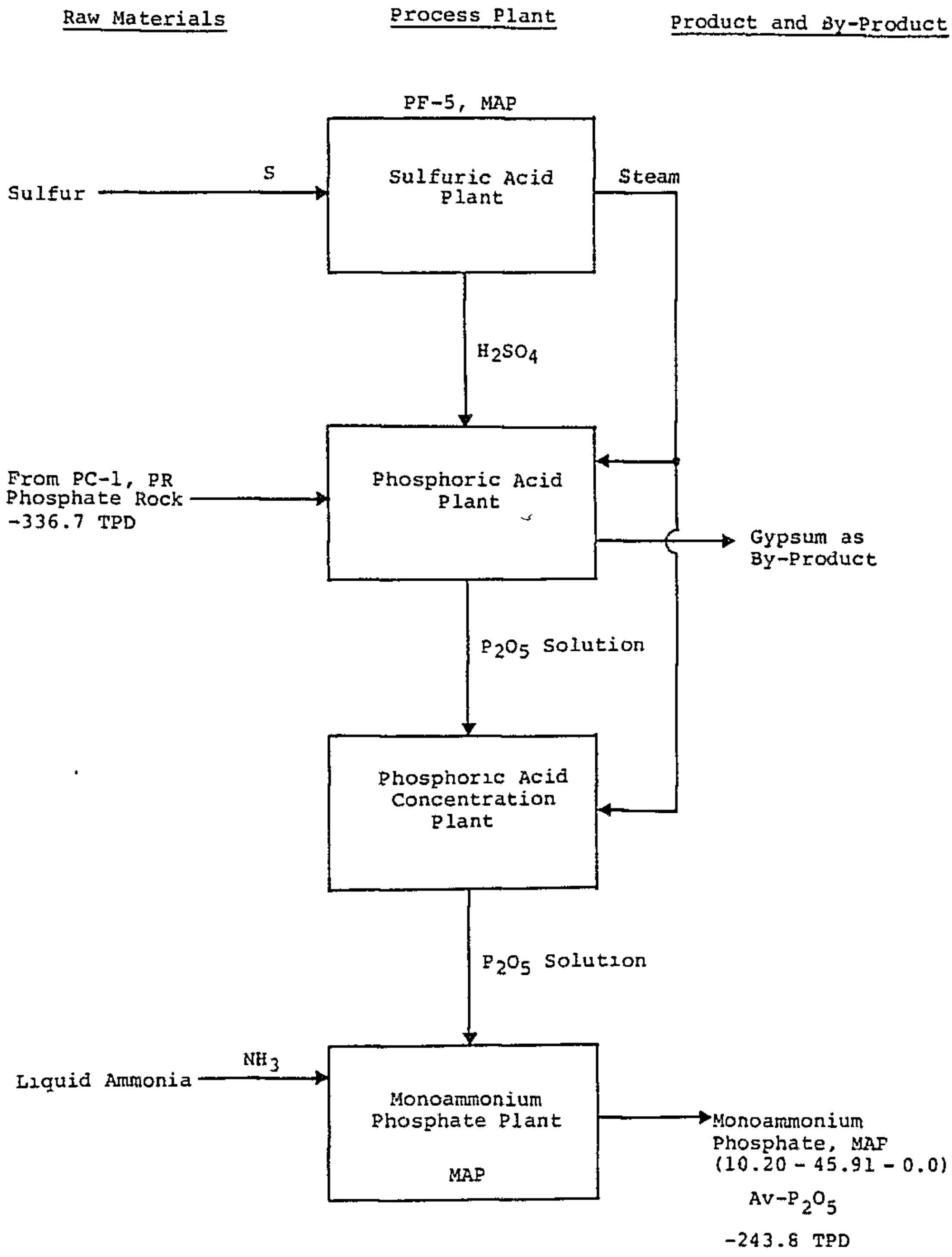


Figure V-2(5) PROCESS SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION -MONOAMMONIUM PHOSPHATES AND COMPOUND FERTILIZERS

Phosphate Fertilizer Project, Argentine

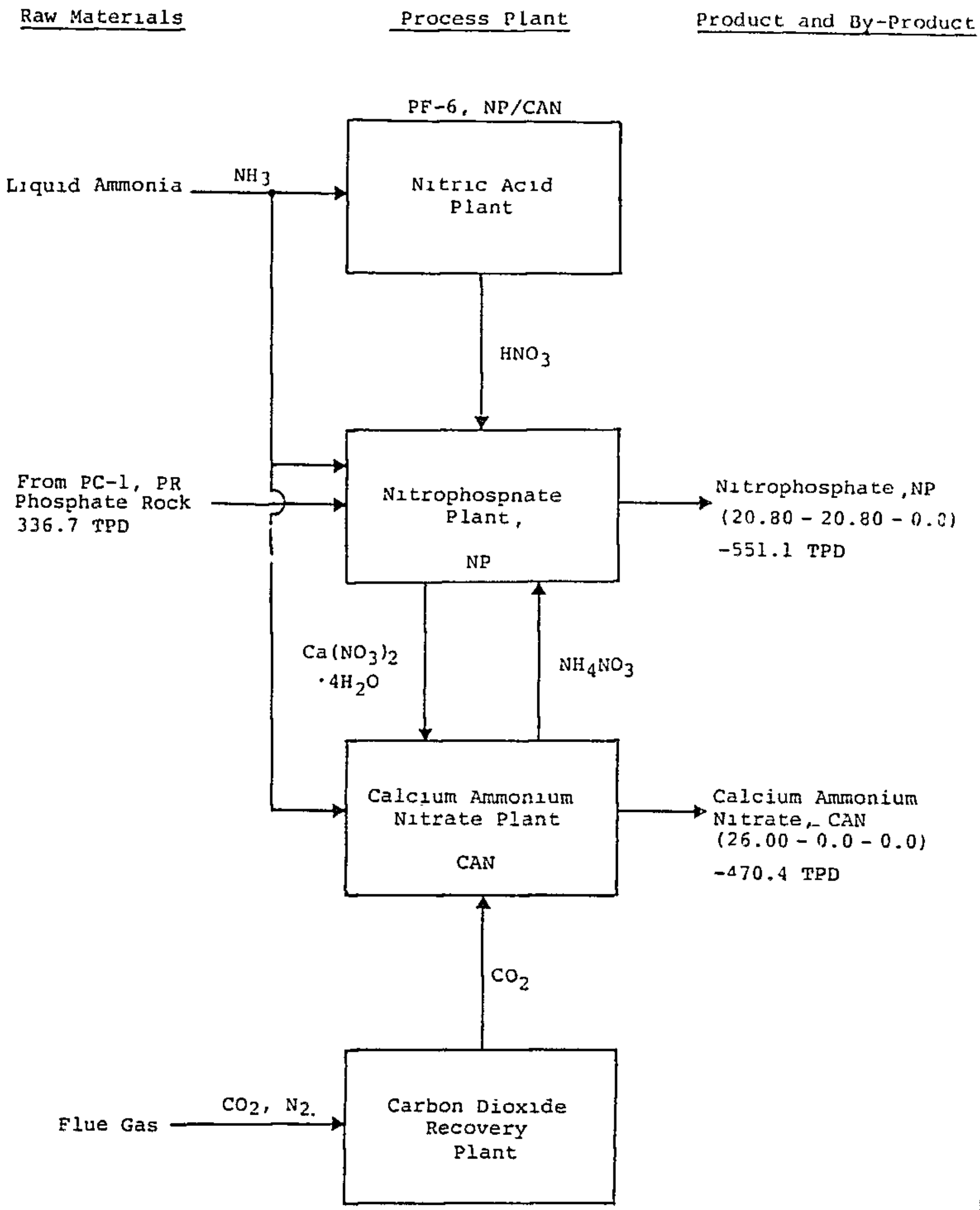


Figure V-2 (6) PROCESS SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION - NITROPHOSPHATE FERTILIZERS ... AMMONIA PURCHASES

Phosphate Fertilizer Project, Argentine

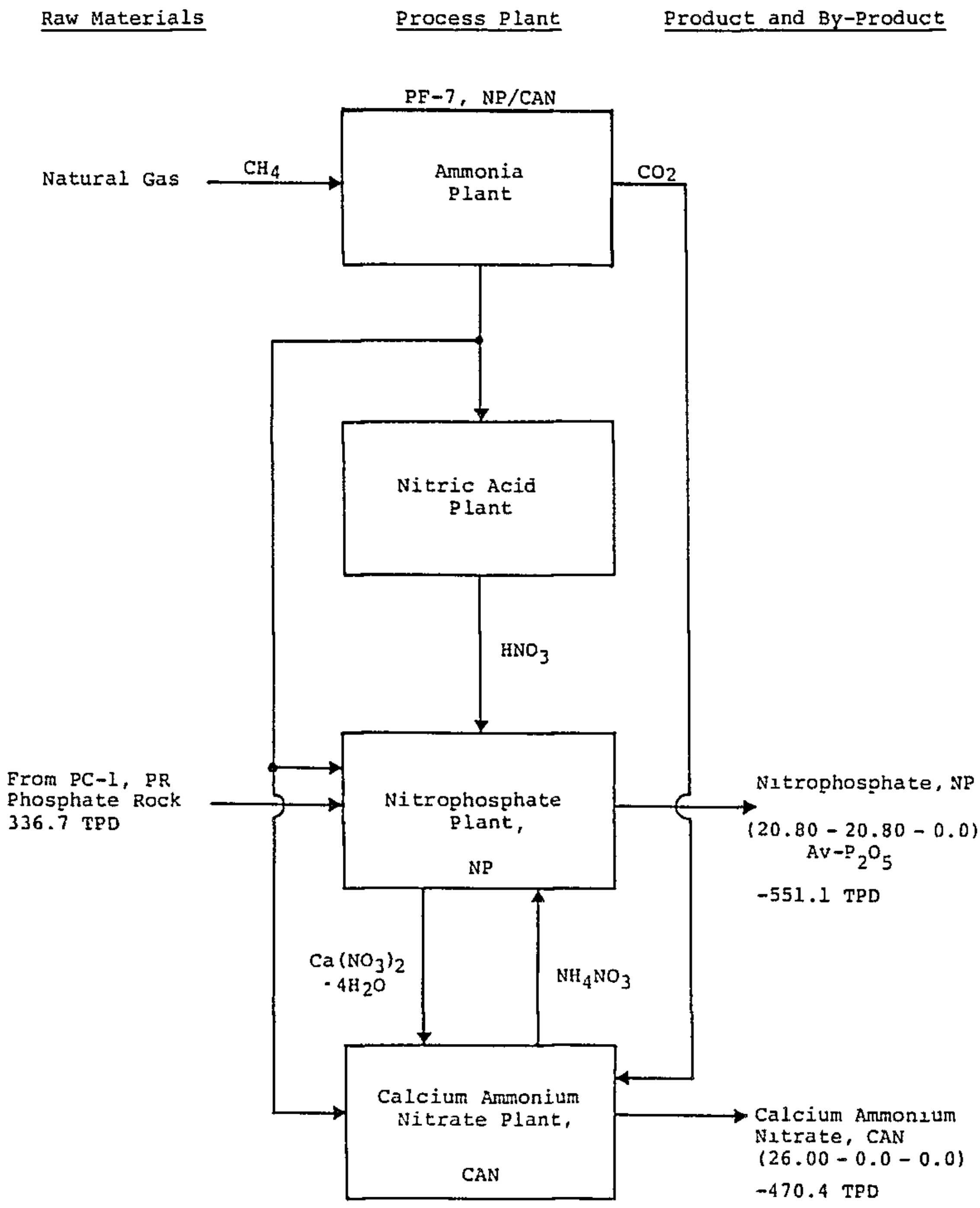
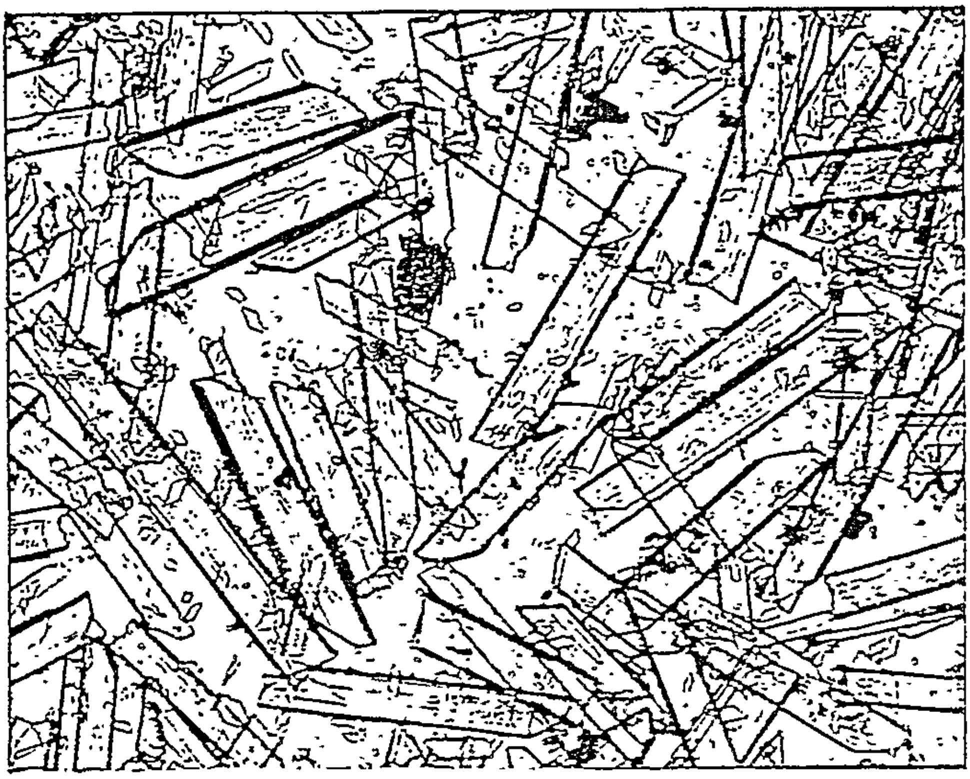


Figure V-2 (7) PROCESS SCHEME FOR PHOSPHATE FERTILIZER PRODUCTION - NITROPHOSPHATE FERTILIZERS ... AMMONIA PRODUCTION



Scale

0 0.05 0.1 mm

Process: Hemihydrate/Dihydrate Phosphoric Acid Process

Phosphate Rock: Extracted from Non-Magnetic Tails of Iron Ore Concentration Plant, HIPASAM, Sierra Grànde, Rio Negro, Argentine

Phophoric Acid: P_2O_5; 30.0%, H_2SO_4; 5.0%,

P_2O_5 Recovery; 97.5%

Figure V-3 MICROSCOPIC PHOTOGRAPH OF BY-PRODUCT GYPSUM

Figure V-4 PROPOSED INTEGRATED PROJECTS FOR PHOSPHATE ROCK CONCENTRATION PLANT AND PHOSPHATE FERTILIZER PLANT IN ARGENTINE

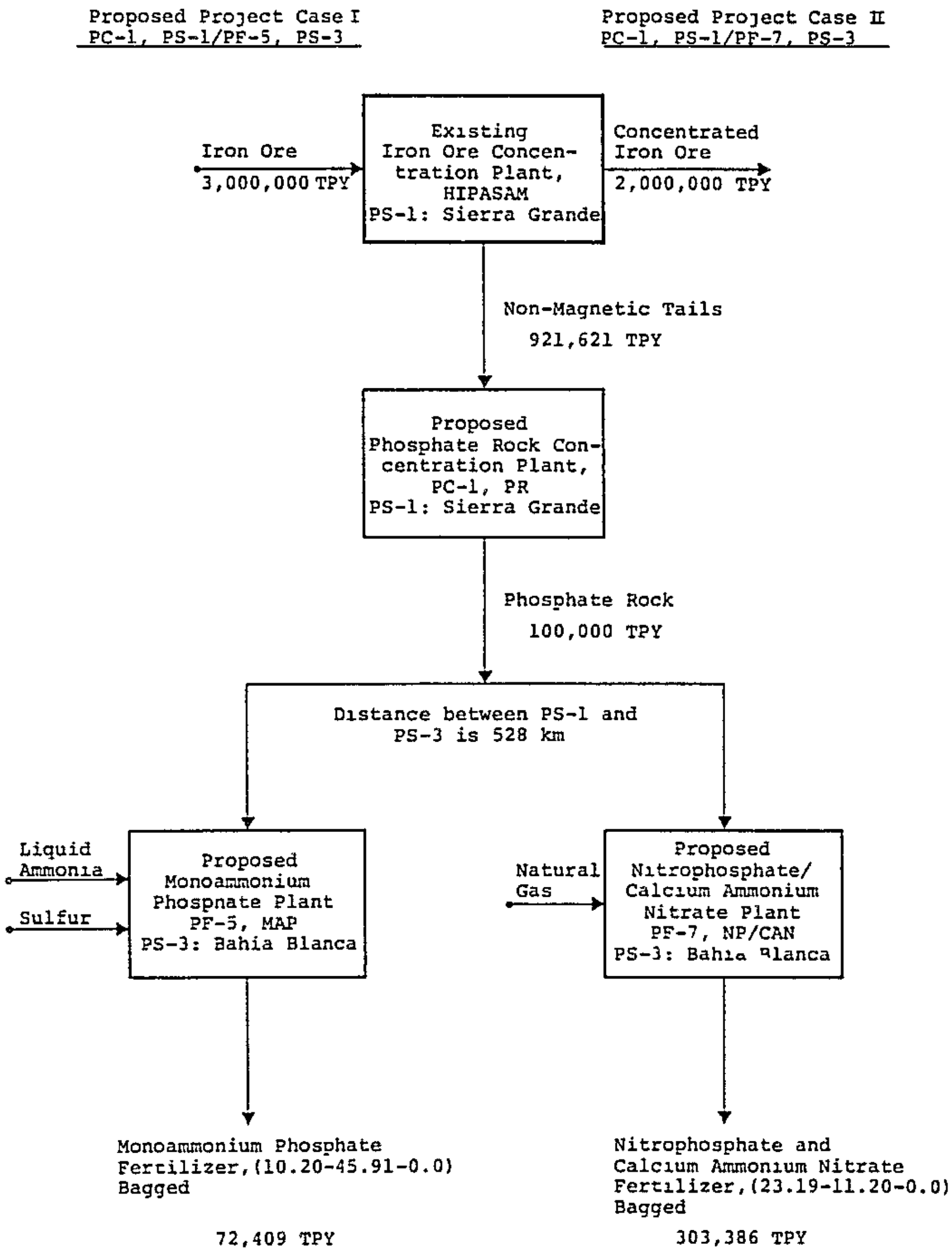


Figure V-5 PROJECT IMPLEMENTATION SCHEDULE

Project: Phosphate Rock Concentration Plant and Phosphate Fertilizer Plant, PC-1/PF-5
Product: Monoammonium Phosphate (MAP), Bagged
Location: Sierra Grande, Rio Negro and Bahia Blanca, Buenos Aires, Argentine
Feasibility Study: On the Establishment of a Phosphate Fertilizer Plant in the Argentine Republic

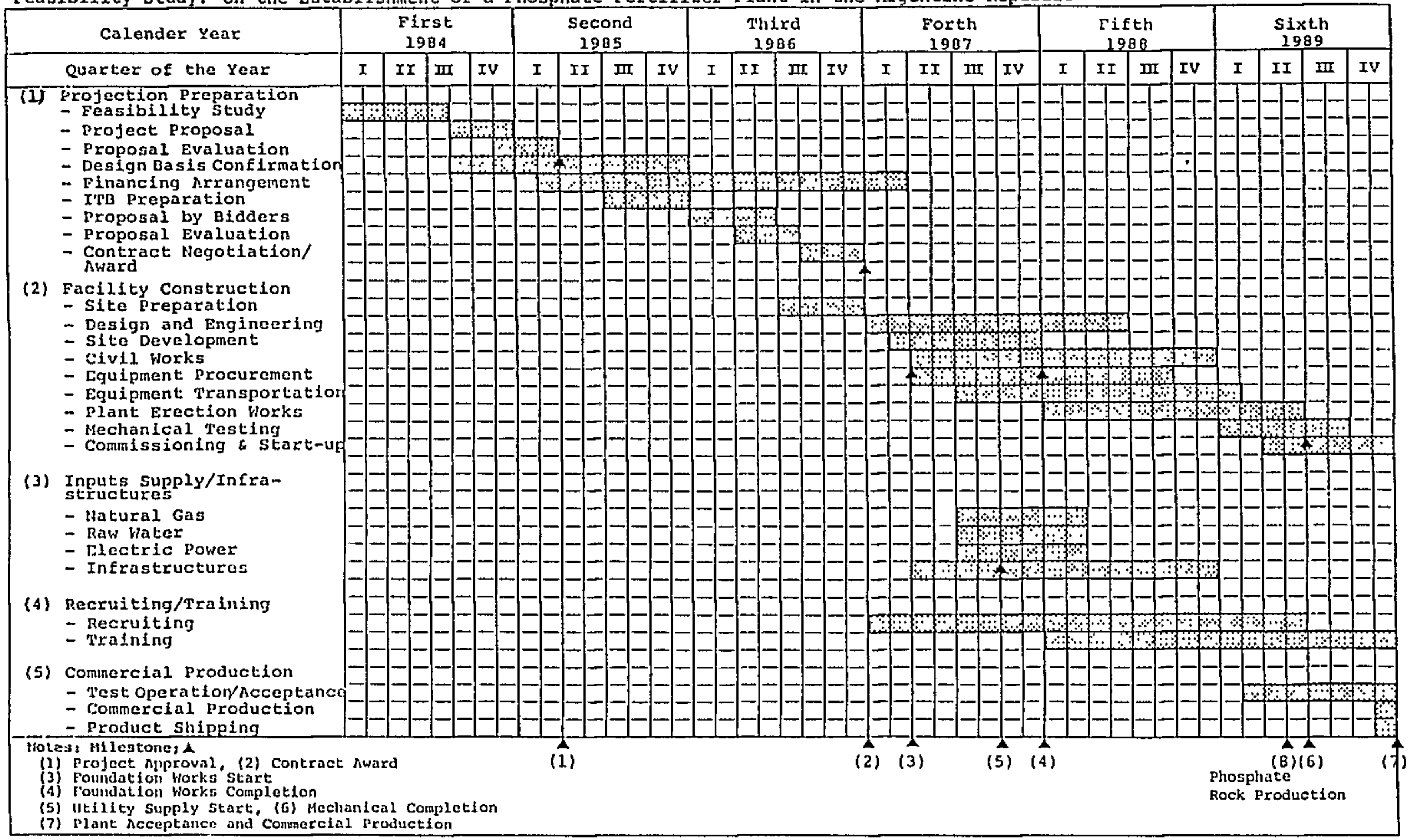


Figure V-6 PROJECT IMPLEMENTATION SCHEDULE

Project: Phosphate Rock Concentration and Phosphate Fertilizer Plant, PC-1/PF-7
Product: Nitrophosphate and Calcium Ammonium Nitrate (NP/CAN), Bagged
Location: Sierra Grande, Rio Negro and Bahia Blanca, Buenos Aires, Argentine
Feasibility Study: On the Establishment of a Phosphate Fertilizer Plant in the Argentine Republic