AIChE - Peninsular Section, Florida

CLEARWATER 1995

Wengfu Chemical Fertilizer Complex
Fuquan County, Guizhou Province
People's Republic of China.

by

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Part 1 - Phosphoric acid, Paul A. Smith

Part 2 - Granular TSP, Sam Houghtaling

PART 1

PHOSPHORIC ACID

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1. PLANT COMPOSITION

The phosphoric acid plant has a capacity of 1000 mtpd P_2O_5 for the WENGFU MINING & FERTILIZER DEVELOPMENT GROUP for incorporation into a fertilizer complex to be set up at Ma Changping town, Fuquan County, Guizhou province, People's Republic of China.

The plant, designed to produce 1000 mtpd P_2O_5 of concentrated phosphoric acid at 52% P_2O_5 from a feedstock of 74 % BPL Yingping phosphate in water slurry form, comprises the following sections :-

Raw Material Storage
Reaction
Filtration
Concentration
Fluorine Absorption
Acid Storage
Gas Scrubbing
Gypsum Disposal

The Reaction and Filtration system consists of one reaction train and one filter, whilst the Concentration and Fluorine Recovery system consists of three identical parallel trains.

2. BASIC PRINCIPLES - CHEMISTRY OF THE PROCESS

The reactor provides the residence time to dissolve the phosphate but **principally** the time to grow filterable crystals of Calcium Sulphate in the dihydrate form.

The chemical reactions taking place in the reactor are extremely complex due to the diversity of minerals and elements in the phosphate fed. However the following principle reactions take place in the attack tank simultaneously.

Main reaction

$$Ca_3(PO_4)_2 + 3H_2SO_4 + 6H_2O \rightarrow 2H_3PO_4 + 3CaSO_4.2H_2O$$

Secondary Reactions

$$Ca_3(PO_4)_2 + H_3PO_4 + 6H_2O \rightarrow 3CaHPO_4.2H_2O$$

$$CaHPO_4.2H_2O + H_2SO_4 \rightarrow H_3PO_4 + CaSO_4.2H_2O$$

$$CaCO_3 + H_2SO_4 + 2H_2O \rightarrow CaSO_4.2H_2O + CO_2 + H_2O$$

The phosphate slurry is introduced to the first compartment of the attack tank where it is dissolved principally by the action of the acidity in the phosphoric acid slurry, in the second compartment the mixed sulphuric acid and phospho-sulphuric acid, the return acid from the filtration section, is added providing the sulphate ions to precipitate the gypsum.

The sulphate must be maintained at a low value where the phosphate is introduced to prevent coating of the phosphate (the unreacted phosphate loss), whilst in the rest of the reactor the sulphate should be maintained at as higher level as possible to minimise the inclusion of di-calcium phosphate in the gypsum crystal (the cocrystallized or lattice loss).

The phosphate slurry from the reactor is filtered and washed counter-currently on a horizontal rotating vacuum filter and the product acid is separated from the gypsum by-product. The wash liquors are returned to the reaction section to control the strength of the product acid and a part of the product acid is recycled to control the solids content of the reactional mass.

As the phosphoric acid strength produced by the dihydrate process is less than the strength required for the production of TSP the acid must be concentrated in a vacuum evaporator.

3. FEATURES AND BENEFITS

PRAYON has the experience of the construction of 19 plants that operate over 1000 mtpd P_2O_5, 13 of which were built by DAVY.

No grinding system is required as the specified particle size of the phosphate rock in the design basis can be used for the Plant without further grinding.

The phosphate is received from the beneficiation plant about 30 miles (47 km) from the chemical plants in slurry form. The dihydrate process is capable of treating the phosphate slurry with a water content of 30%, weight basis and so no drying is required.

The operation of the Dihydrate process at low temperatures and concentrations reduces the demands for high grade materials of construction reducing maintenance difficulties.

The PRAYON process has operated on most of the phosphates available worldwide along with an unrivalled experience of the construction of plants based on pilot-plant operation of unknown or little known phosphates.

It may well be advantageous to add active silica, which is available as a by-product from the aluminium fluoride plant.

This has three benefits :-

a) It combines with the free fluoride ion to reduce the corrosivity of the phosphoric acid slurry.

b) It improves the gypsum crystal form and shape giving better filtration rates.

c) It causes a higher recovery of fluorine from the acid when fed to the concentration unit.

A single 200 m^2 BIRD-PRAYON filter will be used. The quantity of gypsum separated on BIRD-PRAYON tilting pan filters worldwide far exceeds any other type of filter. It is the standard filtration device in the Floridian phosphate industry and has been recently improved with well-tried features such as the "Fast-drain Pans" and better cam track designs enabling a higher rotational speed.

The ratio of effective filtration area to total area is remarkably high (85 %) and the counter-current washing method allows good washing efficiencies with the lower quantities of wash water available with the slurry feeding of phosphate.

A digestion section is used to mature the slurry before filtration, this acid de-supersaturation ensures minimum scaling on the filter and minimum post precipitation in the storage tanks, thus reducing the amount of tank sludge to be returned. It also reduces to a minimum the down-time required for the washing of the filter circuit, normally a weekly wash is used as part of preventive maintenance routine.

The use of PRAYON's proprietary agitator design specifically developed for the conditions in a phosphoric acid reactor means that all the process aspects are covered :-

Upper blades :
The PRAYON GTA surface agitation impellers enable the plants to work on even the most difficult foaming phosphates with very little or no use of defoamer. They also assist the air-gassing effect and the incorporation of reagents fed onto the surface of the slurry.

Middle and Lower blades :
The other two impellers are designed to give the optimum balance of shear and flow. A PRAYON PPR-45 pitched blade turbine is used as the middle impeller and the PRAYON 4-PHT for the bottom set of blades. This combination gives good homogenisation and keeps the tank bottom clean.

The Low Level Flash Cooler, LLFC, has been developed to enable a high slurry flowrate to be attained with a low power consumption, this enables the LLFC to operate at a low δT, about 2 °C, reducing the supersaturation in the cooler which minimises nucleation and scaling. The axial-flow pump has a very low wear rate.

The concentration system, evaporating from 28 - 52% P_2O_5, operates with three identical units in parallel allowing the use of common items of equipment and thus reducing the number of spares.

A Shell & Tube heat exchanger is used with reinforced graphite tubes, this type of concentration section is well established and reliable especially in conditions where the acid has more corrosive tendencies. Advanced process control along with the reinforced tubes prevents tube damage and gives a reliable ensemble which can run up to two weeks between wash cycles. Scaling is minimised by the use of an axial-flow pump with a low power input and high acid recirculation rate giving a small temperature gradient across the heat exchanger.

The layout of the concentration section is such that no boiling occurs in the heat exchanger. All the boiling occurs within the flash chamber, any entrained spray is collected in a high efficiency PRAYSEP droplet separator and returned to the process.

A forced draft cooling tower is used for the cooling water circuit. To prevent contamination of the cooling water and provide a feedstock for the Aluminium Fluoride plant, Fluorine is removed prior to the cooling water condensers by a PRAYON fluorine scrubbing system. Fluosilicic acid containing 20 % w/w H_2SiF_6 and less than 200 ppm P_2O_5 is produced with a fluorine recovery efficiency in excess of 90%, with respect to the recoverable fluorine. The PRAYON design of fluorine recovery unit has been progressively modified to improve the efficiency and reduce the investment cost. The towers used by the old "Swift" process had to be made of an even larger diameter than the evaporator flash chamber to avoid droplet entrainment. The irrigation of this large cross-sectional area requires a very large recirculation and thus a high power consumption.

The multiple nozzles of small diameter have a tendency to plug. The latest PRAYON design is co-current and uses a very small cross-sectional area and a single large non-plugging nozzle. It uses gravity to help separation of droplets followed by a special PRAYSEP high efficiency droplet separator.

4. PROCESS DESCRIPTION

4.1 Raw Material Storage

Phosphate slurry is received over the Battery Limits with a water content of 30% by weight into the Phosphate Slurry Tank, having a buffer stock of approximately 8 hours. It is fitted with the Phosphate Slurry Tank Agitator to maintain solids in suspension. The particle size of the phosphate, having been already ground for slurry transportation, is already fine enough for treatment in the phosphoric acid plant without further grinding. The level in the phosphate slurry tank is kept constant by a level control acting on the drive of the variable speed pump outside the Battery Limits. Recovered silica from the AlF_3 plant, if required, may be added manually to the phosphate slurry through the optional wetting system on the tank roof.

The phosphate slurry is fed to the first compartment of the Attack Tank by the Phosphate Slurry Pump, the slurry density is measured at the discharge of the pump & controlled at a constant value by the feeding of water to the inlet of the Phosphate Slurry Pump.

The feed rate of dry phosphate is calculated from the flowrate as measured by the flow transmitter and the Gamma ray density meter and is maintained at a constant value by the variable speed drive fitted to the Phosphate Slurry Pump.

The sulphuric acid, 93 - 98 % H_2SO_4 monohydrate, is received across the Battery Limits from the sulphuric acid plant into the Sulphuric Acid Storage Tank which has a nominal stock of 10 hours. The tank level is controlled to maintain a constant level in the tank by a signal from the level controller acting on a valve in the supply line which is outside Battery Limits.

The sulphuric acid is normally fed principally to the second & third compartments of the Attack Tank, the Digestion Tank if required, and eventually to the Washing Liquor Storage Tank if sulphuric acid washing is used from time to time.

Defoamer in drums is poured into the Defoamer Tank, the temperature in the tank is maintained by steam coils and high and low level alarms are provided to inform supervisors in the control room of the actions required. The Defoamer Pump is a multi-head dosing pump capable of feeding two points in the reaction-filtration system and also if required the feed line of each of the three Evaporators.

4.2 Reaction

The Attack Tank consists of a monolithic concrete reactor having 6 compartments each fitted with a three-stage agitator with each of the three impellers specifically designed for the required duty. The upper set of blades (PRAYON-GTA design), at the slurry surface, are fitted with radial blades designed to create a splashing effect to kill the eventual formation of foam and to create condition to incorporate reagents being fed to the surface. The middle set are 45° pitched blades (PRAYON PPR-45 design) pumping downwards and radialy which create good mixing within the reactional slurry and incorporate the phosphate feed which is fed below the surface.

The lower set of blades are of helicoidal format (PRAYON 4-PHT design) and are designed to create a large downwards pumping effect to ensure good suspension of solids and prevent depositions on the tank floor.

The tank is fitted with two Attack Tank Vent Collectors which are connected to the gas scrubbing system which maintains the reactor under a slight depression avoiding the escape of evolved gases.

As previously stated in §4.1 the weight of dry phosphate in the phosphate slurry is maintained constant by the variable speed drive on the Phosphate Slurry Pump. The sulphate concentration in compartment #6, measured continuously by the advisory sulphate analyzer and confirmed hourly by manual sampling and analysis, is normally maintained between 30 & 35 g/l SO_3, and can be adjusted by altering the ratio between the total sulphuric acid being fed to compartments #2 & #3 of the attack tank and the dry phosphate flow.

The sulphuric acid is pre-mixed before entry into the Attack Tank with the recycle acid from the filtration section in a Mixing "T" Pipe. The recycle acid can be considered to comprise three components; sulphate ions, product acid and water. The set points of the flow and density of the recycle acid are varied to control the relative amounts of product acid, which controls the solids content at a value of about 35 % w/w, and the water content, which controls the product acid strength at just above 28.0% P_2O_5. The flow of recycle acid is controlled by adjusting the bleed of product acid to the return acid and the density by the resetting of the filter cake wash and/or the wash liquor bleed.

The chemical reactions occurring in the Attack Tank are exothermic and along with the heat of dilution of the added sulphuric acid mean that in order to maintain the reaction temperature at the desired value of 75 - 80°C, to ensure the production of dihydrate crystals, the reaction slurry must be cooled.

This cooling is effected in the Low Level Flash Cooler - "LLFC". This vessel is maintained under vacuum by the LLFC Vacuum Pump and the pressure controlled by an air bleed. The reactional slurry circulated through the vessel by the LLFC Slurry Feed Pump sited in the compartment #6 of the Attack Tank, the return being by gravity to the head of the reaction system, compartment #1.

The evaporation of water from the slurry causes a cooling effect in the slurry and due to the very high recirculation rate, the δT is only 2 °C, supersaturation and scaling are minimised in the flash cooler body, a δT recorder is provided to give an indication of the evaporative load. The high recirculation rate around the reactor provided by the LLFC Slurry Feed Pump also provides acidity and sulphate to the head of the reaction system where the phosphate slurry is fed giving good conditions for dissolution and crystallization.

The vapours released from the LLFC pass to the Precondenser where waste heat from the overhead vapours is use to heat a bleed from the pond water loop for use as a hot water cake wash on the gypsum filter.

The vapours then pass to a Condenser where the condensation is completed by the use of recirculated cooling water from the cooling tower, the cooling water is discharged to a Condenser Seal Tank which overflows by gravity to the cooling water return trench. Any carry-over of fluorine stripped from the cooling tower water is scrubbed prior to the LLFC Vacuum Pump by a simple spray of process water and separated by the Condenser Mist Separator, collected droplets are routed to the Condenser Seal Tank.

The slurry from the sixth compartment of the Attack Tank overflows by gravity to the digestion section which comprises three identical vertical cylindrical Digestion Tanks in series which provide the retention time to finalise crystal growth and reduce acid super-saturation. The reduction of acid super-saturation means that a matured slurry is fed to the gypsum filter reducing the scaling effect and reducing the post-precipitation in the weak acid storage tank.

These Digestion Tanks of Rubber Lined Carbon Steel construction with bricks on the base and partially up the walls are each fitted with Digestion Tank Agitators which have downwards pumping PRAYON 4-PHT axial alow impellers designed to provide a high flow at a low power consumption to mildly agitate the slurry and prevent sedimentation of the solids on the tank base.

A provision for the addition of sulphuric acid to the first Digestion Tank through a H_2SO_4 Feed Pipe is made to allow independent control of the sulphate level in the Attack and Digestion sections. The Digestion Tanks are also vented to the gas scrubber to maintain a slight depression avoiding escape of evolved gases.

The matured slurry from the third Digestion Tank is pumped to the Filter by the horizontal Filter Slurry Feed Pump under flow control by a variable speed drive.

4.3 Filtration

The slurry is fed to the BIRD-PRAYON horizontal rotating tilting-pan vacuum Filter fitted with a pre-separation AC distributor and one external Separator where any entrained droplets are routed to the Hot Water Seal Tank prior to the Filter Condenser where the gases are scrubbed and vapours condensed by the use of process water. The bleed from the system goes as make-up to control the level in the Scrubber Seal Tank and the level in the Filter Condenser seal tank is controlled by make-up of process water.

Vacuum is provided for filtration by liquid-ring Filter Vacuum Pumps which vent to atmosphere via an integral silencer. The filter is fitted with a Filter Fume Hood over 50% of its surface which is vented to the gas scrubbing system.

After the feeding of slurry to the Filter an initial small section without vacuum is provided to allow the larger gypsum crystals to decant and provide a natural pre-coat giving less solids in the filtrate and also reducing cloth blinding. The filtrate legs are directly connected to the filtrate pumps without seal tanks. The next section is the Pre-Sector or Cloudy Port where the initial filtrate of product acid, sometimes cloudy with solids and always slightly diluted by water in the cells and the cloth weave, is discharged. So that this primary liquor does not affect the quality of the product acid, this liquor is discharged to the recycle acid section in the suction line to the Recycle Acid Pump. The balance of the product acid is discharged to the suction of the Filter Acid Pump, from the discharge of this pump the acid equivalent to the production is fed to the Filter Acid Storage Tank via a flow and a density recorders, whilst the quantity of product acid necessary for the control of solids in the reactor is fed into the suction of the Recycle Acid Pump by a flow control valve.

After separation of the mother liquor the gypsum cake is counter-currently washed in two stages. The final stage prior to gypsum discharge being with pond water fed from the Hot Water Seal Tank by the Filter Cake Wash Pump. The flow of cake wash water is reset by the density controller on the recycle acid line to regulate the product acid strength.

The filtrate from the final cake wash drains from the distributor to the suction of the Weak Acid Wash Pump which pumps the filtrate to form the first cake wash. The filtrate from this wash drains from the filter distributor to the suction of the Recycle Acid Pump. In order to rapidly recover from upsets in filtration causing flooding of the filter a hand control is provided on the filter floor to by-pass the weak acid wash directly to the Recycle Acid Pump.

The gypsum after the two-stage washing is discharged to the Gypsum Cake Discharge Hopper by the action of the filter pan rotation to an inverted position and with the help of the Filter Blowing Fan. The discharged gypsum is sprayed with pond water to clean the gypsum chute and provide part of the necessary water to form the gypsum slurry in the Gypsum Re-slurrying Tank which is fitted with the Gypsum Tank Agitator, additional pond water is added to control the level in the Gypsum Re-slurrying Tank prior to pumping to the Battery Limits by the Gypsum Slurry Pumps.

After cake discharge the cloths are washed in the inverted position with warm water from the Scrubber Effluent Pump, the liquor draining into the Gypsum Re-slurrying Tank and later dried by suction of the Filter Drying Fan.

4.4 Concentration

Three identical lines of vacuum concentration operate in parallel, the process description which is identical for all three units applies to the "A" train only.

Weak acid, 28% P_2O_5, from the Evaporator Acid Feed Pump is fed to the Flash Chamber in order to control the boiling temperature of the acid, this is a function of the product acid strength at a constant vacuum.

The vacuum system consists of a direct contact Condenser which is sprayed with cooling water to remove condensibles, the outlet draining to the Condenser Seal Tank, whilst the non-condensibles are removed by a two-stage steam Ejector System fitted with integral inter-condenser also draining through a separate line to the Condenser Seal Tank, this tank overflows by gravity to the cooling water return trench.

The product acid, with 52% P_2O_5, overflows by a stand-pipe in the overflow chamber which maintains a constant level in the Flash Chamber. The acid drains to the suction of the Product Pump which discharges via a flow recorder/integrator to the Product Acid Storage Tank. To control eventual foaming in the Flash Chamber provision is made to feed defoamer from the Defoamer Pump to the weak acid feed line.

Acid is recirculated by an axial-flow Recirculation Pump through the Evaporator Circulator Filter, through the Heat Exchanger and back to the Flash Chamber, the recirculation rate is calculated to ensure a δT, acid inlet to acid outlet, of about 3°C. Typically the inlet and outlet temperatures are 85 and 88°C respectively. The strainer protects the tubes from blockage with large pieces of scale, note this type of axial-flow pump does not require a strainer. The Heat Exchanger has resin impregnated graphite tubes and a carbon steel shell and is situated at an elevation below the liquid level in the Flash Chamber such that no boiling occurs either in the graphite tubes nor in the pipe. The use of this elevation and the low δT ensure that the scaling is minimised.

The steam flowrate is maintained constant by a flow control valve on the LP steam line to the Heat Exchanger and the pressure on the shell-side increases during the operating cycle, the superheat after the reduction in pressure across the flow control valve is eliminated in all conditions by a spray of condensate in a Desuperheater excess condensate draining to the Condensate Tank, the equilibrium steam temperature is an indication of the state of scaling of the tubes and a high temperature alarm notifies that it is time to wash the unit.

The condensate is discharged by gravity through a self-draining self-venting line to the Condensate Tank fitted with a level control which resets the position of the control valve on the discharge of the Condensate Pump. The quality of the condensate is checked for eventual acid leakage by the analyzer and if detected the steam valve is automatically closed, the Condensate Pump stopped, the condensate level control valve tripped closed and the condensate dump valve opened.

A graphite heat exchanger can provide many years of trouble- free service provided that it is not maltreated. A number of interlocks are provided in order to limit the errors that can occur. Firstly the DCS system will be provided with a start-up mode that prevents rapid heating-up and the steam valve will be slowly tripped closed under the following conditions:-

high acid temperature ex-heat exchanger

high steam temperature inlet heat exchanger

high level condensate tank

low level condensate tank

non-rotation of axial-pump shaft

low level in flash chamber

high level in the flash chamber

acid in condensate

If tube breakage does occur then acid will be detected in the condensate and the steam valve will close and the condensate dumped to trench.

Vapours liberated from the recirculating acid pass via the fluorine recovery section, see §4.5, to the vacuum system described above.

4.5 Fluorine Absorption

Vapours liberated from the acid contain principally water, HF, SiF_4 and Cl_2 and to protect the environment and produce a saleable product the fluorine content can be recovered.

In order to ensure that the fluosilicic acid produced is not contaminated with phosphoric acid the vapours initially pass through a PRAYSEP high efficiency Droplet Separator where the small droplets of entrained phosphoric acid are separated and returned to the concentration unit. This unit is fitted with automatic washing by the use of a timed solenoid valve.

The vapours then pass to a co-current PRAYON Fluorine Scrubber where the vapours are scrubbed with fluosilicic acid recirculated by the Fluorine Scrubber Recirculation Pump and dispersed with a special design of non-blocking nozzle. The scrubber liquor drains by gravity to the Fluorine Scrubber Seal Tank which is agitated by the Fluorine Scrubber Seal Tank Agitator.

To maximise recovery and to minimise shut-downs due to scaling, frequent programmed washing of the equipment is automatically incorporated. The Fluorine Scrubber Seal Tank is fed with make-up water and the recirculation maintained. The required density relating to 20% H_2SiF_6 is maintained by the discharge valve. One of the principal reasons for low recovery of H_2SiF_6 in traditional systems is the entrainment of fine droplets of acid, to prevent such an occurrence a PRAYSEP high efficiency Fluosilicic Acid Droplets Separator similar in design to that on the concentration unit outlet is provided, the recovered acid droplets drain to the Fluorine Scrubber Seal tank. The sequenced sprays for cleaning the Droplets Separator are fed with process water.

4.6 Acid Storage,

4.6.1 Weak Phosphoric Acid

The Filter Acid Storage Tank has a buffer capacity equivalent to 3 days of operation and receives 28% P_2O_5 product acid from the gypsum filter via the Filter Acid Pump and is fitted with the Filter Acid Storage Tank Rake to collect the decanted solids for return to the reaction section via the ODS Sludge Pump. The sludge is directed normally to the Attack Tank but can alternatively be fed to the first Digestion Tank.

The weak acid 28% P_2O_5 is fed from the Filter Acid Storage Tank to the three evaporators by the Evaporator Feed Pump which is provided with a variable speed motor.

A portable skid mounted Multipurpose Pump is provided to drain the Attack Tank, the Digesters or any of the storage tanks for cleaning.

4.6.2 Concentrated Phosphoric Acid

Two Product Acid Storage Tanks having a buffer storage equivalent to about 6-7 days receive the 52% P_2O_5 from all three evaporator Product Pumps each fitted with a Product Acid Storage Tank Agitator. Two Product Acid Feed Pumps supply the 52% P_2O_5 to the GTSP plant via a flow recorder/integrator.

4.6.3 Fluosilicic Acid

The fluosilicic acid containing 20% H_2SiF_6, is discharged from each of the three fluorine recovery units and received in the Fluosilicic Acid Storage Tank having a useful buffer storage of approximately four days. The Fluosilicic Acid Pump transfers the acid across the Battery Limits via a flow recorder/integrator to the Aluminium Fluoride plant.

4.6.4 Wash Liquor

The Wash Liquor Storage Tank is a non-agitated sloped bottom tank used for the planned plant washing programmes, both the filter circuit and the three concentration units require washing, the washing of the filter if required may be arranged to coincide with an evaporator wash so that hot water is available for filter washing. It is a closed circuit system and sulphuric acid can be added if so desired.

4.7 Gas Scrubbing

Two separate gas scrubbers are installed one for the reaction and filtration sections the other for the storage area.

4.7.1 Reaction and Filtration

The scrubber system consists of a packed cross-flow Gas Scrubber with a Gas Scrubber Fan drawing gases from the various sections of the reaction and filtration section and discharging to the Stack.

The reactor vent gas from the Attack and Digestion sections and the Filter vent gases are treated separately prior to combining for a final scrubbing section. The scrubber is fitted with three Scrubber Circulation Pumps and one Scrubber Effluent Pump. This pump feeds the cloth wash sprays of the Filter with warm water and make-up water is bled from the discharge of Filter Condenser Pump to control the level in the Scrubber Seal tank.

4.7.2 Storage

A Jet Scrubber is provided to maintain the four storage tanks (Filter Acid Storage Tank, the two Product Acid Storage Tanks and the Fluosilicic Acid Storage Tank) under slight depression preventing the escape of fumes. The motive force for the suction effect is the once through cooling water flow across the venturi section, after the scrubber the cooling water drains to the cooling water trench.

4.8 Gypsum Disposal

The gypsum slurry is pumped, at a solids concentration of approximately 25% solids, from the Gypsum Re-slurrying Tank to the Battery Limits by the Gypsum Slurry Pump. The Gypsum Stack is located a few km away, in the hills. The decanted water is returned to the Phosphoric Acid Plant in a closed slurry transportation loop.

ENCLOSURE I

TECHNICAL SPECIFICATION OF THE PLANT

PRAYON Mk 4 DIHYDRATE PROCESS

including

CONCENTRATION & FLUORINE RECOVERY

1.0 GUARANTEED PERFORMANCE

1.1 Attack and Filtration

Nominal production capacity (acid ex-filter 28% P_2O_5)	NLT	1000 MTPD of P_2O_5
P_2O_5 recovery (filter cake basis)	NLT	96%
H_2SO_4 consumption	NMT	2.68 mt / tP_2O_5 produced

1.2 Concentration

Nominal production capacity (concentrated acid 52% P_2O_5)	NLT	1000 mtpd P_2O_5
with solids content of	NMT	2%
and having an acid strength of	NLT	52% P_2O_5 (solids free basis)
P_2O_5 recovery	NLT	99.8%

1.3 Fluorine Recovery

Nominal production capacity	NLT	51 mtpd fluosilicic acid (100% H_2SiF_6 basis)
with a strength of	NLT	20% H_2SiF_6 (total F reported as H_2SiF_6)
having a P_2O_5 content of	NMT	200 ppm P_2O_5

2.0 DESIGN BASIS

2.1 Phosphate

The phosphate is from the beneficiation plant at Yingping, Guizhou Province and is received as a slurry via a pipeline of 47 km length with the following analyses :

Chemical analysis:

Elements	Concentration - % w/w dry basis
P_2O_5	34.22
CaO	49.30
CaO/P_2O_5	1.44
Al_2O_3	0.18
Fe_2O_3	0.40
SO_3	0.45
F	3.4
SiO_2 Total	6.5
CO_2	3.7
MgO	1.32
Na_2O	0.39
K_2O	0.06
Cl	300 - 500

Size analysis:

NMT 1%	> 35 mesh Tyler	(0.417 mm opening)
12 - 15%	> 100 mesh Tyler	(0.147 mm opening)
55 - 65%	< 200 mesh Tyler	(0.074 mm opening)
c. 35%	< 400 mesh Tyler	(0.0385 mm opening)

2.2 Sulphuric acid

Strength : 93 or 98 % monohydrate
Temperature : ambient.

2.3 Chemical reagents

Silica from the AlF_3 plant may be used as additive, and a Chinese produced defoamer with proven performance in combatting foam in phosphoric acid production may be used.

2.4 Utilities (main)

Power	:	26 kWh/T P_2O_5
Process water	:	3 T/T P_2O_5

WENGFU GTSP PLANTS

By S.V. Houghtaling
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Background:

Twin 55 tph GTSP plants will be constructed at the Wengfu site in Fuquan County, Guizhou Province of the Peoples Republic of China. Mitsui Engineering and Shipbuilding Co,. LT., Japan has the contract for Project management and to supply the Process Packages and the equipment to the China National Technical Import and Export Cooperation, People's Republic of China. Hydro Agri International Licensing, Belgium will supply the Process Package for GTSP plant. HiTech Solutions, Inc, Lakeland Fl, USA will supply the Process Package for the material handling to Hydro Agri International. This same team has a 55 tph GTSP plant under construction at Anning in Yunnan province. Picture of the Anning plant will be shown later.

The Phosphoric Plant will be a Prayon dihydrate design supplied by Prayon of Liege, Belgium to Mitsui.

Rock Supply:

Phosphate Rock slurry is pumped 70 km to the site. The rock slurry is 60% minus 75 microns and a majority is feed to the Phosphoric Acid Plant. A portion of the slurry is ground to 80 % minus 75 microns for GTSP feed. The rock Yingping rock is high grade and not as reactive as Florida rock. Yingping rock is 67 on the Reactivity Index and Florida rock is 71 on the Reactivity Index. Ref 1

Process:

Raw Materials are 54% Phosphoric Acid and 68% Solids Phosphate Rock Slurry. The two raw material are ratioed into two agitated reactors in series. The slurry is pumped to a Granulator which discharges into a Drier. The Drier discharges to a belt conveyor that feed the Ex-Drier Elevator. The Ex-Drier Elevator feeds the Screen Feed Drag Flight Conveyor. Four coarse Derrick Screens are fed by a the Drag Flight Conveyor. The course material from the Coarse Screens is feed direct to four Chain Mills which discharge into the Recycle Drag Flight Conveyor.

The fines material from the Coarse Screen flow through a diverter that send only the amount required for product to the two fines screens. The two fines screens are feed by a Fines Screen Elevator. The fines from the product screens go to the recycle Drag Flight which feed the Recycle Elevator. The Recycle Elevator feed the recycle of 8 to 1 to the Granulator.

The product is fed to a Fluid Bed cooler and coating drum before being conveyed to storage. Cyclones are provided for the Drier, Cooler and Dust gases. These gas streams then go to Gas scrubbers out of HiTech responsibility. The Cyclone solids go to the recycle conveyor.

The Granulator and Drier will be constructed in China. The Fans, Elevators, Screens, Pulverizers, Drag Flights, Gates & Diverters and entire GTSP Rock Grinding system will be furnished from the United States.

The building construction will be Concrete. All design is metric. The detail Design will be performed by the Wengfu Design Institute. Hydro Agri will furnish the Process Package which includes the material handling portion from HiTech Solutions.

The major difference in the material handling is a third elevator to feed the two fines screens. Only two screens are required since only the amount required to produce the production rate is fed to two screens. The height of the plant is reduced and still have single deck screens. Derrick screens were selected due high efficiency with four different angles on each screen. Our opinion is that one of the reason this team was selected for the last three GTSP plant in China is the lower cost arrangement.

Reference:

1. Developments in TSP Production, N. Ward & B. Crozier Hydro Agri International, IFA Technical Conference-1992, The Hague Netherlands 1992

Figure 1

Location of Chinese Phosphate and TSP Projects

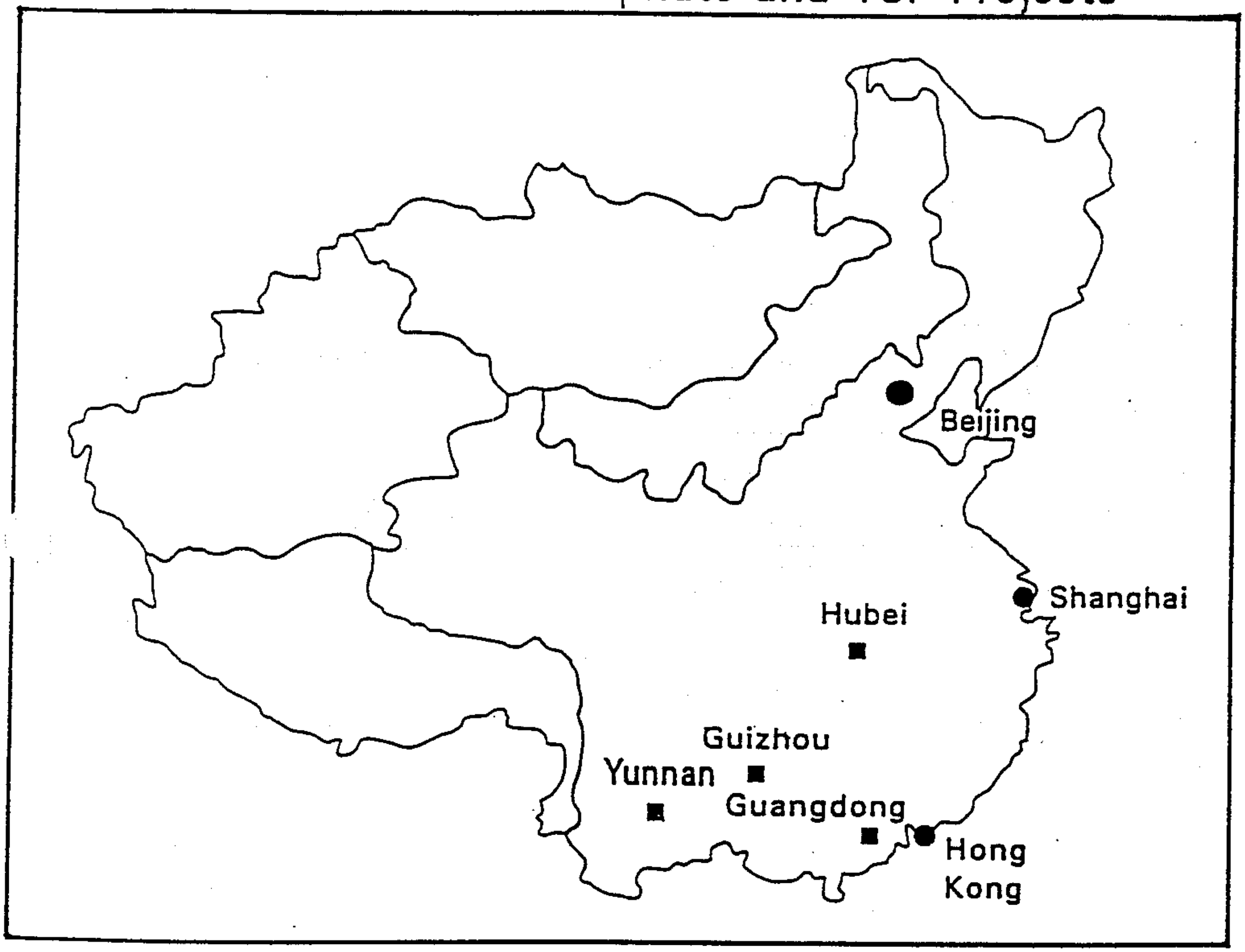

TABLE 1

CHINESE PHOSPHATE ROCK TESTED FOR TSP

Source of Phosphate	Name of Phosphate	TSP Project
Yunnan Province	Jian Shan Jinling	Anning Yunfu
Guizhou Province	Yingping	Wengfu
Hubei Province	Dayukou	Dayukou

TABLE 2

TYPICAL CHEMICAL ANALYSIS

Component % wt/wt	PHOSPHATE			
	Jian Shan	**Jinling**	**Yingping**	**Dayukou**
P_2O_5	31.8	31.2	35.1	33.3
CaO	44.7	43.2	50.3	46.8
SO_3	0.38	<0.3	0.63	0.50
F	2.70	2.85	2.92	2.70
CI	90 ppm	180 ppm	450 ppm	146 ppm
SiO_2	16.2	15.7	3.85	9.13
AI_2O_3	1.04	0.85	0.33	0.44
Fe_2O_3	1.12	0.96	0.35	0.54
MgO	0.25	0.55	1.06	1.77
Na_2O	0.23	0.34	0.16	0.18
K_2O	0.26	0.07	0.17	0.28
CO_2	2.25	2.38	3.70	4.36

Figure 2

Comparison of Rock Reactivities