PROCESS DESCRIPTION OF SUPERPHOSPHATE PLANT

2.1 GENERAL

2.2 PLANT INPUT

2.2.1 GROUND PHOSPHATE ROCK

Density	1.0
Temperature	Ambient to 70 ^oC
Angle of Repose	Variable, depending on temperature (0^o to 80^o)

2.2.2 SULPHURIC ACID

80 % H2SO4 received by pipeline with the following characteristics:

Strength	80%
SG	1.720 - 1.740
Temp.	20-40 c
Rate	12-30 tph as 100 % H2SO4
Hg	4 ppm maximum
Colour	Dark

2.2.3 SULPHUR

Strength	99% minimum
Size Range	1-2 mm
Shape	"Pastilles"
Colour	Yellow

2.3 PLANT OUTPUT

2.3.1 PRODUCTION PRODUCT SPECIFICATIONS

The specifications sets out a product that will mature chemically in the storage sheds to a product that after de-dusting & screening will meet the dispatch specifications. Note that the product is not dried in the process & relies on a loss of moisture in the maturing heap due to the heat of reaction & evaporation.

2.3.2 DISPATCH PRODUCT SPECIFICATIONS

Superphosphate

Density	1.1
Temperature	Ambient to 70 ^oC
Angle of Repose 35^o	

These describe the quality of the product to be despatched from the works.

2.4 PROCESS DESCRIPTION

2.4.1 INTRODUCTION2.4.1.1 Main Processes

The process in superphosphate granulation plant can be grouped in the following main areas of operation:

Ground Rock Receival, Storage and Recycle System
Mixer and Den Operation
Granulation Process and final Product Storage
Air Scrubber Systems

These are further explained below.

2.4.1.2 Material in Process

Material in process through the plant will have a typical composition as shown below.

Typical Operating Temp	60^o to 70^o C
Operating Pressure	Ambient
Material Bulk Density	1080 kg/m3
Material Composition	90% Single Superphosphate
	10% Unreacted phosphate rock

With the following also present

8 - 10% Moisture as water, fluorosilicic acid
(Including dissolved salts)
6 - 7% Unreacted Phosphoric Acid

2.4.2 GROUND ROCK RECEIVAL, STORAGE AND RECYCLE

2.4.2.1 Road Bin & Ground Rock Storage Bin

Ground phosphate rock is transported in 28 tonne capacity sealed semi-trailers. The nominal rate of transfer is 28 tonnes per hour.

The road bin (50F01) has a capacity of 15 tonnes & the trucks are controlled by traffic lights operated by level switches in the bin. The bin feeds a 100 tph screw, elevator & screw system to a 200 tonne storage bin (50F02).

The bin has high level alarms & an extra high level alarm stops the road bin screw (50P01) to avoid overflowing the bin.

2.4.2.2 Ground Rock Recycle System

The ground rock (GR) from the storage bin is fed to a bucket elevator via an air slide which is pressurised by a blower. Fluidity of the GR is adjusted manually by adjusting air flow to the air slide canvasses.

The elevator feeds a transfer screw (50P09) which supplies the GR weigher WIT607 with excess feed to demand to give a constant head feed to the weigher . The excess GR is delivered to a surge GR bin 50F03 which recycles back to the elevator boot.

The surge bin is 140 tonne capacity but will control in the lower half capacity. This is to allow for shutdowns of the bucket elevator which needs to be empty at shutdown.

The level indication, high level and extra high level alarms are achieved by load cells in the bin support bays. The readout is % of total capacity.

The flow rate to the surge bin will normally be 5-10 TPH. The flow from the bin will be 5-10 TPH **except during a startup of the mixer feeds** when the full flow of ground rock to the mixer will come from the surge bin until the flow from WV637 is established. The air slide 50 P11 therefore needs to have 40 TPH capacity.

The system adjusts to varying demands of the ground rock weigher by a level controller in the surge bin by adjusting the damper at the end of the second air slide - 50P07.

Drives start remotely in a nominated sequence on one command. The air slide blower can then be stopped without shutting down the system. This feature is used to empty the system of GR into the surge bin on shutdowns.

2.4.3 MIXER & DEN OPERATION

Control system

Fixed Inputs

The control system controls the process within limits keyed into the control programme. The variation of the inputs is subject to a graded access system . These fixed inputs are listed in 2.6.3.

2.4.3.1 Ground Rock Supply

Ground Rock (GR) is supplied by weigher 50P10 at a rate controlled by the MCR. The rate range is limited by selection of product codes which have fixed inputs for minimum & maximum flows.

The GR flow is the primary flow in the control system as it determines production rates.
Acid & scrubber liquor flows are controlled according to the GR rate.

A manual gate on the feed box to the weigher is set at the beginning of each rate adjustment to optimise weigher operation.

Referring to the interlock diagram, stopping the weigher shuts off other feeds but does not shut off the premixer & mixer drives. The premixer & mixer can then be run out & flushed before shutdown.

2.4.3.2 Premixer & Mixer Drives

The premixer & mixer have to be running before the feeds can be started. The mixer drive is a variable speed AC unit with fixed input minimum & maximum speeds.

Mixer drive has overload warning alarms at fixed input levels to allow process technicians to take feeds off & run down the product load in the mixer prior to the unit shutting down.

2.4.3.3 Sulphuric Acid Supply

Sulphuric Acid is pumped from storage tanks at the Pasminco smelter west of the site using one of their pumps. The pump is started by Pasminco technicians but can be stopped by a command from the MCR.

Acid flow is adjusted according to a fixed input acid/ rock ratio. This ratio is defined as tonnes of H_2SO_4 measured as 100 % H_2SO_4 (monotonnes)/ tonnes of dry basis ground rock.

The acid strength is nominally 80 %. Scrubber liquor is added at the premixer & the Mixer to dilute the acid to a final acid strength set by a fixed input strength.

The control circuit for this scrubber liquor flow requires the following inputs:-

GR weigher:	tph	Signal
Acid/Rock Ratio		Fixed Input
H_2SO_4 Magflo	mtph	Signal
GR moisture		Fixed input
H_2SO_4 Monitor	% H_2SO_4	Signal
Final Acid Strength Target	% H_2SO_4	Fixed Input

The following functions are performed to calculate the flow & control the flow:-

1 The acid flow rate is set by applying the acid/rock ratio to the GR weigher output. The acid ratio controller sets the flow at this rate assuming the feed acid is 80 % strength. The strength monitor output is used to correct the flow to the correct mono tonnes.

2 The output from the magflo at this new flow is then used in a mass flow calculation to determine the mass of scrubber liquor to dilute the acid to the final attack strength target. The flow control is then by variable speed peristaltic pumps with flow measurement by magflos.

2.4.3.4 Premixer Operations.

The premixer's function is to mix scrubber liquor from the primary scrubber liquor pump with GR to prewet the GR to improve contact between the acid & rock in the mixer. The scrubber liquor + moisture in the GR drops the H_2SO_4 to approximately 73% H_2SO_4.

2.4.3.5 Control of Mixer Operation

The mixer is a single shafted mixer of two compartments. The first section has larger paddles that mix the 80 % H_2SO_4 with the wetted GR.

The second compartment has smaller Kneading paddles that work the reacting slurry to assist the rate of reaction which is starting to slow down due to a loss of moisture level due to hydration, steam losses & saturation with dissolved salts.

Retention time in the mixer is controlled by adjusting the revs of the paddles, the selection of the type of paddles plus their condition. Current retention time is 1.5 - 2.0 minutes.

The aim is to have a slurry leaving the mixer that is still reacting but sets quickly

2.4.3.6 Reactions in the Mixer.

Ground phosphate rock of a specified blend ,ground to a specified sizing (Ref. MS-07-001F) reacts with the sulphuric acid in an exothermic reaction that results in the evolution of gases such as HF, SiF_4 & CO_2. Temperatures reach 130-140 C at the first section of the mixer but are typically 110 - 120C at the exit of the mixer.

Refer to the chemical reactions listed in the attached appendix “A”.

The sulphuric acid is typically consumed in the first part of the mixer forming Phosphoric Acid which then reacts with the remaining phosphate rock to form Calcium Di Hydrogen Orthophosphate & other forms of Phosphate according to the levels of contaminants eg Iron & Aluminium.

The gases formed in the mixer are vented off to the scrubbers under suction as are the gases formed in the den.

The rate of reaction is influenced by:-

Reactivities of the Phosphate rocks used
Sizing of the Ground Rock
Levels of contamination eg Iron & aluminium.
Temperatures of raw materials.
Water content
Retention time in the mixer.
Acid/Rock ratio

The slurry has a high gaseous content & mixing is needed to “knead” as much of the gases out of the slurry to minimise expansion in the den.

Secondary scrubber liquor addition is added to the second section of the mixer to increase the moisture level to assist the reaction rate & provide sufficient liquid phase for granulation.

2.4.3.7 Den operation

The purpose of the den is to hold the slurry from the mixer for sufficient time so that it can expand, set & consume most of the phosphoric acid. The usual retention time is 10 - 20 minutes.

The retention time is varied by varying the den floor speed.. The den floor speed is varied automatically so that the cake leaving the den is:-

1. Dry enough for the cutter to easily cut through it.
2. The total liquid prase is optimum for granulation.

2.4.3.8 Effect of Mixer Den Operation on Production

Any variation to the reaction rate of the raw materials affects the retention time required in the den prior to the den cake being added to the granulation system. The process technician has manual control of the retention time with the den speed control. Automation of the den speed is available to the plant technician after the plant is on line. The % undersize material passing through the primary screen controls the den speed. The result is an automated system of granule size control.

Raw material variations can also have an effect on the rate of reaction & cause variation in the total liquid prase of the den cake with a constant den floor speed. The high recycle rate of the granulation circuit plus the increased material mass in the circuit is designed to give the circuit sufficient inertia to minimise the effects of such changes. Circuit components such as the piano wire screens are designed to handle a wet sticky product.

1 Fixed inputs restrict the range of raw material flows to the mixer are designed to keep reaction rates close to optimal for any combination of raw materials & for any of the nominated products. The process technician 's role is to adjust the scrubber liquor flow to the mixer so as to keep the den speed drive operating in an automatic made within it's allowable speed range.

2.4.4 GRANULATION PROCESS AND FINAL PRODUCT STORAGE

2.4.4.1 Primary Disintegrator

The primary disintegrator efficiently reduces the den cake material to a fine (< 1.0 mm) particle size & also input energy to the material in preparation for granulation (SSP den cake is thixotropic). The spillage coming from the two weighers in number 3 shed also go through the disintegrator & are also reduced in size & mixed with the den cake . The spillage picks up heat from the den cake (usually 95c) which assists granulation of this material.

The efficiency of the disintegrator is controlled by the pressure in the air bag that controls the pressure of the disintegrator rotor against the nip rotor. The pressure is controlled by the disintegrator rotor motor amps to a set point. The expected set point is expected to be about 100 amps.

2.4.4.2 Granulator

The granulator is 4.3 metre diameter. The work imparted onto product by this unit make denser granules that will give better abrasion resistance. The hardening agents already added to the rock blend (Xmas rock) are added to given even higher abrasion resistance.

The granulator operation is optimised by adjustable angle & rotation speed.

The granulatoris lined with flexible rubber liners that are self cleaning & must be flexible enough to also act as lifters to the product.

The entry weir is as high as possible to avoid spillage from the front of the granulator during high recycle / low angle operation.

The water sprays to the granulator are atomising sprays to allow general wetting of the product to bring the moisture level up to the optimum for granulation. Flow is not expected to generally go above 25 lpm.

The granulator liners are extended past the shell in a frame with 100 mm holes cut in the rubber. the holes are to spread the product over the screen feed conveyor which is the receiving conveyor from the granulator. There is enough gap between the end of the liners & the outlet chute to allow lumps bigger than 100mm to fall through.

2.4.4.3 Primary Piano Wire Screen

The screen consists of two screens & cleaners (ie working spare) with a winch wire changeover. The wires are tensioned at 100 psi & set at a gap of6.0 mm.

Cleaning combs are stainless steel that project between the wires & cover the full width of the screen. Cleaner operates continuously but park out of the product when the plant is stopped.

Due to the spreading of the wires under product pressure the actual size cutoff is 6.0 - 6.7 mm.

2.4.4.4 Undersize Product From The Primary Screen

The % undersize from the primary screen (ie <6.7 mm) is used to automatically control the den speed.

The weigher on 50 P 83 monitors the amount of undersize from the primary screen.

2.4.4.5 Product Recycle Splitter Chute

The undersize from the primary screen is close to the specified size for product except for some + 5.0 mm granules (which are removed by the secondary screen).

The product recycle splitter chute diverts some of this undersize (ie product) back into the recycle to act as seed granules in the granulator.

The splitter operation is controlled automatically to obtain a steady 300 tph of product recycling around the granulation circuit.

The splitter chute is an important feature of the granulation circuit as it will stabilise variations in the circuit.

The amount of product going to the secondary screen is monitored by the weigher on 50 P 84.

The amount of product returned to the recycle is monitored as the difference of the weighers on 50 P 83 & 50 P 84.

2.4.4.6 Primary Screen Oversize

The oversize from the primary screen is a function of the

Average granule size from the granulator.
The efficiency of the primary screen
The % of the screen area available for screening (ie unblocked)
The flow rate from the granulator.
The effective screen wire gap under operating conditions.

The screen chosen operates at 60 % efficiency at 300 tph recycle loads.

The difference between the weighers on 50 P 80 & 50 P 83 indicates the flow rate of oversize from the primary screen.

2.4.4.7 Control of Granulation Circuit

Once feeds are established & the recycle around the granulation system is 300 tph , the system is placed in automatic operation.
The automatic operation results in :-

- Recycle rate is controlled by the recycle flap operation to 300 tph.
- Moisture levels are kept at optimum levels for granulation by the den floor speed. The den speed is controlled by the primary screen efficiency which is related to the granule size range. Current primary screen efficiency is set at 55%.
- Granulation water rates are set by the rate of addition of recycled product to the granulation circuit.

2.4.4.8 Secondary Screen Operation

The secondary screen is a ”polishing” screen that acts removes the + 5 mm product left in the product after the primary screen.
The screen gap is 5 mm with an effective size cut off of 6mm.

The screen efficiency (ie % undersize) is optimally 60 -70 %. Operation above this figure results in the automatic diversion of the product to a recycling heap.

2.4.4.9 Product Leaving Plant

The product leaving the plant is sampled by an automatic sampler & the sample obtained reduced in size using a sample splitter. The remaining sample is then divided into one sample for local sizing analysis & one for complete analysis .

The physical quality of the product is inspected regularly visually as well as the above tests.

2.4.4.10 Maturing the Product

The product is conveyed to storage sheds where is allowed to mature chemically. During this time most of the remaining phosphoric acid is consumed as it reacts with the unreacted phosphate rock.

Dispatch specifications require a phosphoric acid level of less than 1.0 % & this is referred locally as " free acid ".

There is some heat generated from this reaction & some moisture loss. The heap sets due to the high moisture content (7 %) & some "wet cap " forms on the top of the heap.

The recovery operation involves removal & recycle of the "wet cap " & the break up of the set by tracked excavator & front end loader. Smaller lumps of agglomerated granules are broken up by a tyne feeder as the product is fed onto the conveyor feeding the de-dusting & screening plant.

The dust & any oversize (+6mm) is conveyed back to the recycle heap for reprocessing.

The product is sampled at dispatch & sent to the Kooragang Island laboratory for complete analysis.

2.4.5 AIR SCRUBBER SYSTEMS

2.4.5.1 Scrubber Operation Specification

Refer SPEC-51-001A.

This specification sets out the acceptable operating conditions in the scrubbers. Operation outside these conditions is not allowed under any circumstance.

2.4.5.2 Gaseous Loads on Scrubber from Mixer and Den

Load varies with the source of the phosphate rock. The Fluoride load usually depends upon a combination of Fluoride & Silica levels as Silicon tetrafluoride is the usual Fluoride form reaching the scrubbers. The amount of Fluoride evolved varies from about 5% to 30 % or more for different rocks. The current blend would evolve about 30 % of it's Fluoride.

Carbon Dioxide is also formed & most is scrubbed in the odour scrubber.

Some rocks have stronger odours when acidified & the odourants are usually hydrocarbon sulphides.

2.4.5.3 Fluoride Scrubbers

The SiF_4 is easily scrubbed with a 4 pass counter current water scrubber followed by a 2 pass alkaline Hypochlorite odour scrubber.

The Fluoride is converted to Fluorosilcic acid in the first 4 passes & is then consumed as process liquor in the mixer.

Silica is precipitated during the first three passes & is kept in suspension using high volume Warman centrifugal pumps.

Any remaining SiF_4 is scrubbed out by the alkaline last two passes.

2.4.5.4 Odour Scrubber

The odour scrubber is a 2 pass crossflow type scrubber using “Kimre” pads as the scrubbing medium irrigated by horizontal sprays.

Odourants are first removed from the gas stream with the alkaline liquor & the oxidant (NaOCl) then converts the odorous sulphides to sulphates.

Alkalinity is maintained by a pH control system dosing 50 % Sodium Hydroxide in the passes 5& 6.

Oxidant level is controlled by ORP probes.
The system is flushed by water additions to pass 6.
Liquor flow is counter-current to the gas flow by pump tanks overflowing to the preceding pump tank.

2.4.5.5 Instrumental Control of the Odour Scrubber

Ref. P&ID Scrubbers
Ref. Environmental Specifications

The scrubbers are operated according to a strict set of specifications with alarms when the units operate outside their limits for more than 5 minutes. The specifications have been developed from operating experience backed up by olefactometry & specialized gas analysis using mass spectrophotometry.

2.4.5.6 Proposed Fluorosilicic Acid Plant.

A plant to prepare store & export Fluorosilicic acid is under consideration & this plant would be controlled by the control system. This plant will remove the need to recycle the acid from the Fluoride scrubber back to the process.

APPENDIX A

SINGLE SUPERPHOSPHATE

Produced by two parallel reactions

i) $Ca_3(PO_4)_2\ CaX + 2H_2SO_4$ $Ca(H_2PO_4)_2 + 2CaSO_4 + CaX$

apatite sulfuric acid monocalcium phosphate calcium sulfate

ii) $2Ca_3(PO_4)_2\ CaX + H_2SO_4 \sim 2Ca(H_2PO_4)_2 + 4CaHPO_4 + 2CaX$

dicalcium phosphate

Single superphosphate has a total phosphorous content of 9% comprising.

30% $Ca(H_2PO_4)'$ water soluble
10% CaHPO~ citrate soluble
45% CaSO~

10% Iron, Aluminium oxides
5% Water