

# Fertilizer production

## Introduction

### **Production of fertilizer**

Fertilisers are used to accelerate growth and increase the yield of plants. They are of high importance for agriculture in order to add nutrients to the soil, which have been detracted by the crops. They are often adjusted in order to consist of the nutrients needed by a specific crop. The main components are nitrogen, phosphorus and potassium, but also sulphur, calcium, magnesium and micronutrients can be added. There are two different types of fertilisers. Mineral fertilisers consist of inorganic salts of the nutrients and are usually synthesised. Organic fertilisers are of animal or herbal origin, but can also be synthesised (for example urea).

Characteristic for organic fertilisers is the linkage of the nutrients to carbon.

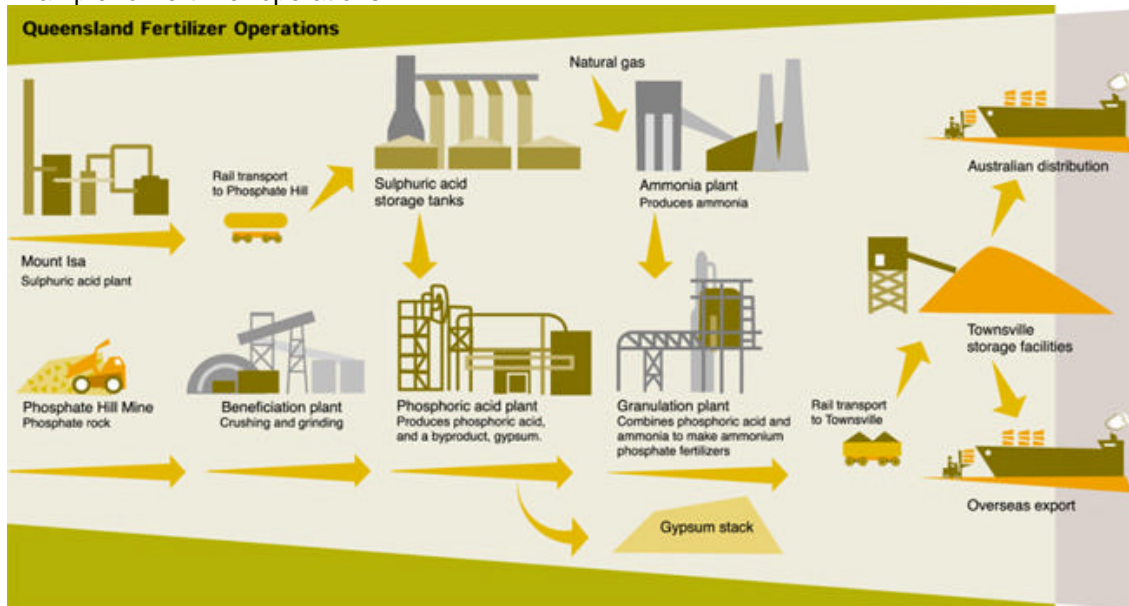


The majority of manufacturing processes for Complex Fertilizers are based on dissolution of phosphate rock in mineral acid followed by neutralisation, concentration and finally, granulation or prilling. In some processes sulphuric acid is used for the dissolution of phosphates. The calcium originating from the rock is then extracted as gypsum, a waste material that can cause environmental problems.

Five main production steps / locations:

- 1.) Sulphuric Acid Plant
- 2.) Phosphate Facilities
- 3.) Phosphoric Acid Plant
- 4.) Ammonia Plant
- 5.) Granulation Plant

Example for fertilizer operations:



### 1.) Sulphuric Acid Plant

The production of sulphuric acid involves first collecting and then cleaning the sulphur dioxide in a two-stage gas scrubbing process before converting it to sulphur trioxide and then to liquid sulphuric acid. The acid is then piped to storage tanks on site before being pumped via two pipelines to the rail loading station or other ways for transportation.



## 2.) Phosphate facilities

The phosphate rock is mined and is transported by truck or other ways to the Phosphate processing facilities.

The beneficiation plant converts the rock into a slurry form. The rock is delivered by truck to the plant where it is crushed, washed and then de-slimed. The ore is transferred to the ball mill and ground into slurry. The slurry is then filtered, thickened and stored in large storage tanks, ready for use in the phosphoric acid plant.



## 3.) Phosphoric Acid Plant

Phosphoric acid is produced by combining the phosphate slurry from the beneficiation plant with sulphuric acid.

The acid reacts with the rock in large reactors and produces phosphoric acid. Gypsum crystals are formed as a bi-product of this process. Large belt filters separate the gypsum and any undissolved rock from the phosphoric acid.



## 4.) Ammonia Plant

Ammonia is another important feedstock, and its availability is critical for the final stages of fertilizer production. Ammonia is produced basically from water, air, and energy. The energy source is usually hydrocarbons, thus providing hydrogen as well, but may also be coal or electricity. Steam reforming of light hydrocarbons is the most efficient route, with about 77% of world ammonia capacity being based on natural gas.

The liquid ammonia is stored at atmospheric pressure at minus 33 degrees Celsius in a large tank.

Ammonia is usually stored by using one or other of three methods:

- Fully refrigerated storage in large tanks with a typical capacity of 10,000 to 30,000 tonnes (up to 50,000)
- Pressurised storage spheres or cylinders up to about 1700 tonnes
- Semi-refrigerated tanks



### 5.) Granulation Plant

The final phase of fertilizer production takes place at the granulation plant. In a carefully controlled environment, the phosphoric acid produced is combined with the liquid ammonia to form ammonium phosphate slurry.

This slurry is then pumped into the granulator where it forms granules of fertilizer, which are then dried, screened and coated.



### Market segments

- Producer of sulphuric acid
- Producer of phosphoric acid
- Producer of ammonia
- Installation contractors & control manufactures

### Description of the challenge

#### **Sulphuric Acid Plant**

There is always a risk of accidental pollution when chemicals are produced and handled. The highest risk for accidental pollution is during the transportation of the product. There is also a risk of pollution from the storage of sulphuric acid and different plants have different systems to collect leaks and spillages depending on guidelines for the storage of acid.

Gas leaks are measured by monitoring the SO<sub>2</sub> content in the air.

### Phosphoric Acid Plant

Major hazards in phosphoric acid installations are not expected provided in the design of all the used.

The chance of an acid spill from storage tanks is very small, with the highest risk being a leak from the tank because of corrosion. Corrosion with phosphoric acid is a relatively slow process and starts with a small hole in the tank. Normally the leak will be seen and the tank emptied before a significant spillage can take place. The risk is minimized if the tank is adequately banded. There is a risk of the loading pipe cracking during phosphoric acid loading and this could lead to a significant uncontrolled spillage.

Phosphoric acid is a corrosive liquid of low toxicity that may cause burns on skin and eye contact and irritation in the respiratory tract.

Phosphoric acid is not explosive or flammable but in contact with ferrous metals less resistant than type 316 stainless steel, it liberates hydrogen gas which is explosive in the range 4-75% by volume of hydrogen in air. Contact with strong caustic substances must be avoided as the reaction is exothermic and produces splashes. A dangerously high concentration of fluoride gases often builds up in phosphoric acid storage tanks.

### Ammonia Plant

Emissions during normal operation are negligible. Major leaks of ammonia from storage tanks are almost unknown with most of the leaks which do occur being during transport or transfer.

Historical data show that the major accidents in ammonia plants are explosions and fires. In addition there is also a potential of toxic hazard due to the handling and storage of liquid ammonia.

The following credible major hazards events are identified in an ammonia production plant:

- Fire/explosion hazard due to leaks from the hydrocarbon feed system.

- Fire/explosion hazard due to leaks of synthesis gas in the CO removal/synthesis gas compression areas (75% hydrogen).

- Toxic hazard from the release of liquid ammonia from the synthesis loop.

In ammonia storage the release of liquid ammonia (by sabotage) is a credible major hazard event.

The most important toxic components are CO from potential leaks in the synthesis gas generation and shift areas and NH<sub>3</sub> from leaks in the ammonia synthesis and ammonia handling areas. In partial oxidation plants H<sub>2</sub>S and SO<sub>2</sub> are present in the sulphur removal/recovery sections. Traces of carbonyls (iron and nickel) may form during operation.

Suffocation due to lack of oxygen may occur at points where the breathing air has been diluted with inert gases. In ammonia plants CO<sub>2</sub> and N<sub>2</sub> are potentially suffocating gases.

**Selection of relevant substances**

name	Carbon monoxide	Carbon dioxide	Methane	Ammonia	Hydrogen
formula	CO	CO <sub>2</sub>	CH <sub>4</sub>	NH <sub>3</sub>	H <sub>2</sub>
MAK <sup>1</sup>	30 ppm	5000 ppm		50 ppm	
IDLH	25 ppm			300 ppm	
LEL	10.9 Vol %		4.4 Vol %	15,4 % by vol.	4 Vol %
attributes	- colourless and odourless gas - as heavy as air - very toxic - flammable	- heavier than air - non flammable - toxic, colourless, non smelling gas	- colourless gas - extremely flammable	- toxic, colourless, pungent-smelling gas - corrosive - lighter than air - explosive when mixed with air	- colourless and odourless gas - lighter than air - highly flammable
name	Hydrogen sulphide	Nitrogen dioxide	Sulphur dioxide	Oxygen	
formula	H <sub>2</sub> S	NO <sub>2</sub>	SO <sub>2</sub>	O <sub>2</sub>	
MAK <sup>1</sup>	10 ppm	5 ppm	2 ppm		
IDLH	100 ppm	20 ppm	100 ppm		
LEL	4.3 Vol %	12.5 Vol %			
attributes	- is colorless, - highly flammable - very light	- very toxic - corrosive - oxidant - liquefied gas - non flammable	- toxic, colourless, pungent-smelling gas - non-combustible - very good solvent - produces H <sub>2</sub> SO <sub>4</sub> (acid rain)	- oxidant, strongly supports combustion - non flammable	

<sup>1</sup>all values are from 2003, subject to change<sup>2</sup>TLV-values**Solution from Dräger**

Most of the occurring substances and / or gases are lighter than air, only carbon dioxide is heavier than air and would displace oxygen and / or breathable air. In this case the transmitter and or the intake should be mounted close to the floor.

In particular the Dräger Polytron 7000 with integrated pump, Remote-Sensor and relay module fits the requirements for this application.

With the wide range of different electrochemical sensors in combination with the long life time and the very good technical qualities Dräger can offer complete solution.

Following DrägerSensor are possible for the detection:

- DrägerSensor CO for the measurement of CO  
(Measurement range: 0 – min 50 ppm / max.. 1000 ppm, Lower detection limit: 5 ppm) and /or (Measurement range: 0 – min 200 ppm / max. 5000 ppm, Lower detection limit: 10 ppm)
- DrägerSensor O2 for the measurement of O2  
(Measurement range: 0 – min 5 Vol % / max.. 25 Vol %, Lower detection limit: 0.2 Vol %) and / or (Measurement range: 0 – min 5 Vol % / max. 100 Vol %, Lower detection limit: 0.4 Vol %)
- DrägerSensor NH3 for the measurement of NH3  
(Measurement range: 0 – min 300 ppm / max.. 1000 ppm, Lower detection limit: 30 ppm)

and / or (Measurement range: 0 – min 50 ppm / max. 200 ppm, Lower detection limit: 5 ppm)

- DrägerSensor H<sub>2</sub>S for the measurement of H<sub>2</sub>S  
(Measurement range: 0 – min 10 ppm / max.. 100 ppm, Lower detection limit: 1 ppm) and / or (Measurement range: 0 – min 5 ppm / max. 100 ppm, Lower detection limit: 0.5 ppm)
- DrägerSensor NO<sub>2</sub> for the measurement of NO<sub>2</sub>  
(Measurement range: 0 – min 5 ppm / max. 100 ppm, Lower detection limit: 0.3 ppm)
- DrägerSensor SO<sub>2</sub> for the measurement of SO<sub>2</sub>  
(Measurement range: 0 – min 5 ppm / max. 100 ppm, Lower detection limit: 0.5 ppm)
- DrägerSensor H<sub>2</sub> for the measurement of H<sub>2</sub>  
(Measurement range: 0 – min 500 ppm / max. 3000 ppm, Lower detection limit: 15 ppm)

Detection of Carbon dioxide can be performed with Polytron IR CO<sub>2</sub> in the range of 0 to 30 Vol%. The optical measuring technique guarantees the highest level of reliability and self diagnostic features.

For the detection of flammable Gases is Polytron IR the first choice for this application. One common calibration gas like Propane can be used for calibration. During normal operation several target gases can be selected from the internal gas library. Polytron IR requires no re-calibration to the target substance when it is part of the internal gas library.

The Polytron IR Ex provides lower measuring ranges. Therefore it suits well for any leak detection application.

Polytron Pulsar for fence-line detection and coverage of larger areas.

The detection principle of Hydrogen depends on the concentration. For higher concentration as a flammable gas the catalytic bead sensor is the first choice for this application. It has a very short t<sub>90</sub> time of only 5 seconds for hydrogen and it is available from Dräger in a 0-100% LEL and in 0-10% LEL version. For high temperature applications above 65°C we recommend the HT version of the pellistor.

### Application of the different Dräger measuring transmitter

Transmitter	CO	NH <sub>3</sub>	H <sub>2</sub>	NO <sub>2</sub>	H <sub>2</sub> S	SO <sub>2</sub>	O <sub>2</sub>
Polytron 3000 <sup>2</sup>	✓	✓	✓	✓	✓	✓	✓
Polytron 7000	✓	✓	✓	✓	✓	✓	✓
Polytron 2	✓	✓	✓	✓	✓	✓	✓
Polytron 2 XP	✓	✓	✓	✓	✓	✓	✓
Polytron TX <sup>1</sup>	✓	✓	✓	✓	✓	✓	✓

<sup>1</sup> Polytron TX is limited for the sensor type

<sup>2</sup> Polytron 3000 has a defined measuring range for each sensor - not configurable (s. datasheet); calibration gas is not always available in the needed concentration

**Sources:**

<http://www.fertilizer.org/ifa/activities.asp>  
<http://www.efma.org/index.asp>  
<http://www.extension.umn.edu/distribution/cropsystems/DC2326.html>

This application note was supported by  
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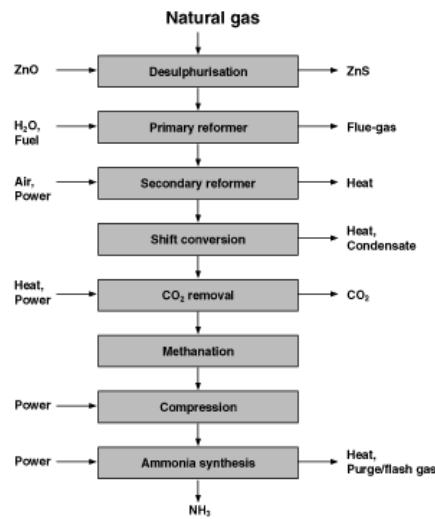
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**Reference list:**

Country	Customer	Gas 1	Gas 2
Austria	AGRO LINZ MELAMIN GMBH	Polytron 2 NH3	
Belarus	PO Azot, Grodno	Polytron SE Ex	
Belarus	PO Azot, Grodno	Polytron Cl2	
Belarus	PO Azot, Grodno	Polytron NH3	
Belarus	PO Azot, Grodno	Polytron SE Ex	
Belarus	PO "Belaruskalyi" Soligorsk	CO	
Canada	Saskfercs/UHDE Fert.Plant,BellePLai	Polytron 1 NH3	
Egypt	Abu Qir fertiliser III	Polytron NH3	Polytron CO
Egypt	Suez Fertiliser Company	Polytron NH3	Polytron CO
France	HYDRO AGRI FRANCE, Tremontines	Polytron 2 NO2 LC	
France	Soferti, Bordeaux	Polytron NH3	
France	Soferti, Fenouillet	Polytron 2 NH3	
Germany	Kali, Bad Hönning	Polytron 2 SO2	
Germany	Kali-Chemie	Polytron NH3	Polytron Ex/SE Ex
Germany	SKW Pistaritz	Polytron NH3	Polytron IR CO2
Germany	SKW Trostberg	Polytron NO2	Polytron SE Ex
Germany	SKW Trostberg	Polytron 2 CO	Polytron Ex/SE Ex
Germany	B + K Steinfeld	Polytron NH3	
Great Britain	Schering Agrochemicals	Polytron Cl2	
Great Britain	Rhone Poulenc Agriculture	Polytron O2	
India	Rashtriya Chemicals & Fertilisers	Polytron NH3	
India	Rashtriya Chemicals & Fertilisers	Polytron CO	
India	Rashtriya Chemicals & Fertilisers Ltd., Thal	Polytron 2 CO	
India	Chambal Fertilisers & Chemicals Ltd.,	Polytron ND Ex	
India	Chambal Fertilisers & Chemicals Ltd.,	Polytron NH3	Polytron ND CO



**Appendix - Block diagram of the steam/air reforming process**



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