F11 FERTILISERS

FROM ROCKS TO FERTILISERS

CHEMICAL INDUSTRIES
RESOURCE PACK

Nitrophosphate process

The nitrophosphate process (also known as the Odda process) was a method for the industrial production of nitrogen fertilisers invented by Erling Johnson in the city of Odda, Norway, around 1927.

The process involves acidifying phosphate rock with nitric acid to produce a mixture of phosphoric acid and calcium nitrate.

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

The mixture is cooled to below zero degrees Celsius, where the calcium nitrate crystallises and can be separated from the phosphoric acid.

The resulting calcium nitrate is used as nitrogen fertiliser. The filtrate is composed mainly of phosphoric acid with some nitric acid and traces of calcium nitrate, and this is neutralised with ammonia to produce a compound fertiliser.

$Ca(NO_3)_2 + 4H_3PO_4 + 8NH_3 \rightarrow CaHPO_4 + 2NH_4NO_3 + 3(NH_4)_2HPO_4$

If potassium chloride or potassium sulfate is added, the result will be NPK fertiliser. The process was an innovation at the time, requiring neither the expensive sulfuric acid nor producing gypsum waste.

As already mentioned, the calcium nitrate can be worked up as calcium nitrate fertiliser, but often it is converted into ammonium nitrate and calcium carbonate using carbon dioxide and ammonia.

$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$

Both products can be worked up together as straight nitrogen fertiliser. Although Johnson created the process while working for the Odda Smelteverk, his company never employed it. Instead, it licensed the process to Norsk Hydro, BASF, Hoechst, and DSM. Each of these companies used the process, introduced variations, and licensed it to other companies. Today, only Yara (Norsk Hydro), BASF, AgroLinz, and GNFC still use the Odda process. Due to the alterations of the process by the various companies who employed it, the process is now generally referred to as the nitrophosphate process.

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Sulfur

Sulfur is significant to agriculture in two ways - as a plant nutrient and for its importance to the processing of phosphate rock into phosphate fertilisers. In the past 20 years, sulfur has been increasingly recognised as an essential ingredient for plant nutrition because it is a component of amino acids, proteins, fats, and other compounds found in plants. The increased use of fertilisers that contain little or no sulfur and the decrease in atmospheric sulfur deposition from industrial emissions have resulted in lower soil sulfur content and increasing soil sulfur deficiencies worldwide. Sulfur for plant nutrition can be applied directly as elemental sulfur, sulfur-bentonite mixes, ammonium sulfate, potassium sulfate, or superphosphates. Nearly 60 percent of all sulfur consumption is in the production of phosphate fertilisers. Nearly 10 percent of additional consumption is used in other agricultural applications, including the production of nitrogenous fertilisers and plant nutrient sulfur. The largest sources of elemental sulfur are petroleum refining and natural gas processing at numerous facilities.

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Sulfur powder

Roll sulfur

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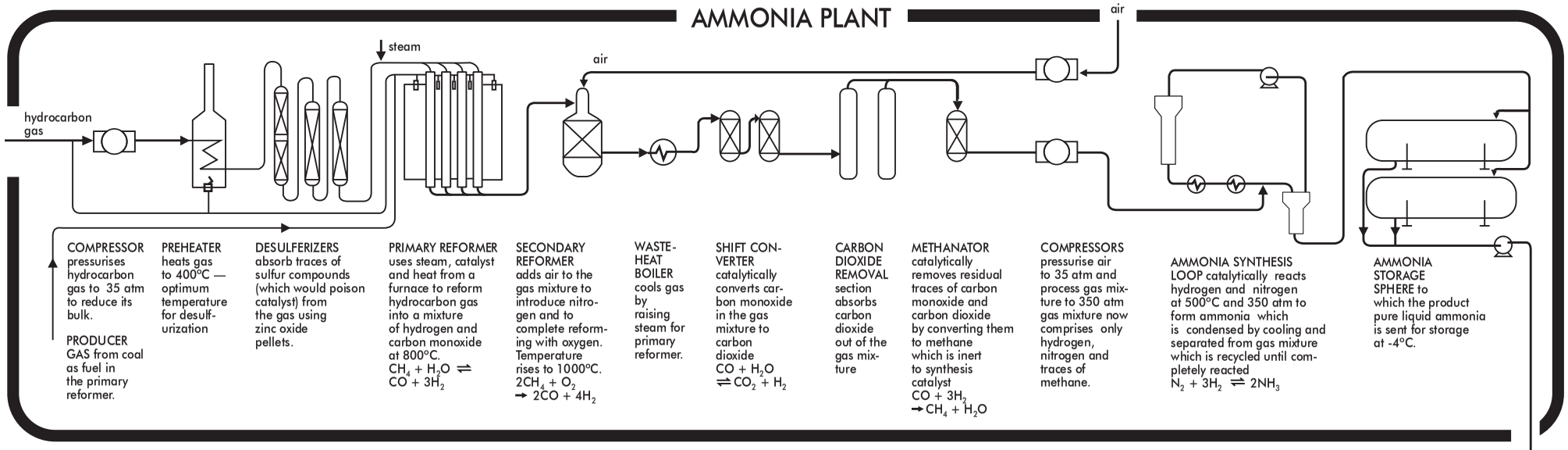
AMMONIA PLANT



COMPRESSOR pressurises hydrocarbon gas to 35 atm to reduce its bulk.

PRODUCER GAS from coal as fuel in the primary reformer.

PREHEATER heats gas to 400°C — optimum temperature for desulfurization

DESULFERIZERS absorb traces of sulfur compounds (which would poison catalyst) from the gas using zinc oxide pellets.

PRIMARY REFORMER uses steam, catalyst and heat from a furnace to reform hydrocarbon gas into a mixture of hydrogen and carbon monoxide at 800°C.
$CH_4 + H_2O \rightleftharpoons CO + 3H_2$

SECONDARY REFORMER adds air to the gas mixture to introduce nitrogen and to complete reforming with oxygen. Temperature rises to 1000°C.
$2CH_4 + O_2 \rightarrow 2CO + 4H_2$

WASTE-HEAT BOILER cools gas by raising steam for primary reformer.

SHIFT CONVERTER catalytically converts carbon monoxide in the gas mixture to carbon dioxide
$CO + H_2O \rightleftharpoons CO_2 + H_2$

CARBON DIOXIDE REMOVAL section absorbs carbon dioxide out of the gas mixture

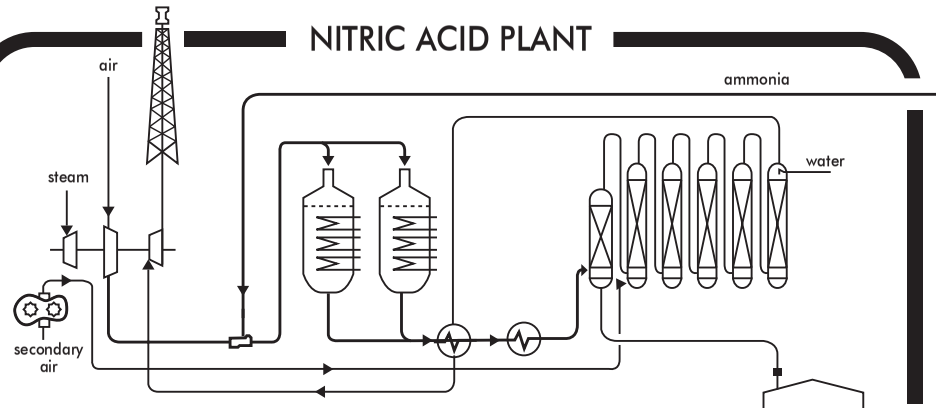
METHANATOR catalytically removes residual traces of carbon monoxide and carbon dioxide by converting them to methane which is inert to synthesis catalyst
$CO + 3H_2 \rightarrow CH_4 + H_2O$

COMPRESSORS pressurise air to 35 atm and process gas mixture to 350 atm gas mixture now comprises only hydrogen, nitrogen and traces of methane.

AMMONIA SYNTHESIS LOOP catalytically reacts hydrogen and nitrogen at 500°C and 350 atm to form ammonia which is condensed by cooling and separated from gas mixture which is recycled until completely reacted
$N_2 + 3H_2 \rightleftharpoons 2NH_3$

AMMONIA STORAGE SPHERE to which the product pure liquid ammonia is sent for storage at -4°C.

NITRIC ACID PLANT



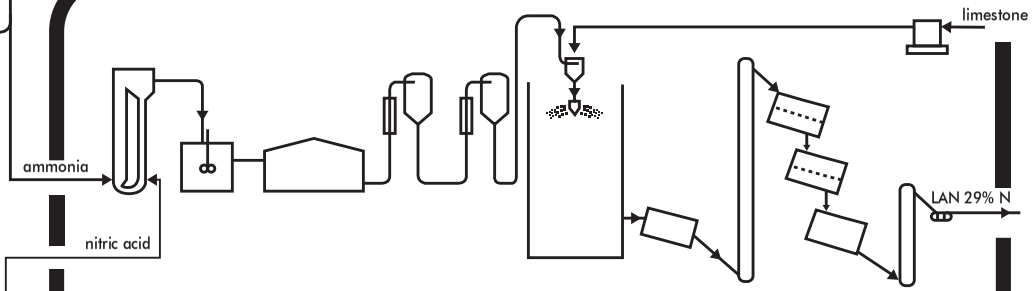
TURBOCOMPRESSOR compresses large air volume to 3 atm and is driven by steam turbine and tail-gas turbine.

MIXER introduces about 10% ammonia vapour into air stream

CONVERTERS in which ammonia reacts with air while passing through platinum catalyst gauzes to form nitrogen oxides. Temperature rises to 900°C and hot gases are cooled by raising steam
$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

ABSORPTION TOWERS absorb the nitrogen oxides in water to form 18% strength nitric acid, which is sent to storage tanks
$2NO + O_2 \rightleftharpoons 2NO_2$
$3NO_2 + H_2O \rightleftharpoons 2HNO_3 + NO$

LIMESTONE AMMONIUM NITRATE PLANT



NEUTRALIZERS (first and second stages) react ammonia vapour with nitric acid to form ammonium nitrate solution, 82% strength.
$NH_3 + HNO_3 \rightarrow NH_4NO_3$

STORAGE TANK stores 82% ammonium nitrate solution

EVAPORATORS concentrate the ammonium nitrate solution in two stages: first to 96% then to 99%

PRILLING TOWER in which finely ground limestone is added to the ammonium nitrate solution and the molten slurry is sprayed down the tower from a spinning perforated bucket.

COOLING DRUM where the solidified beads of LAN are cooled further

SCREENING AND COATING DRUM where fines and oversize pills are removed and anti-caking agent is added to the LAN before it is sent to storage and dispatched via a weightbelt.