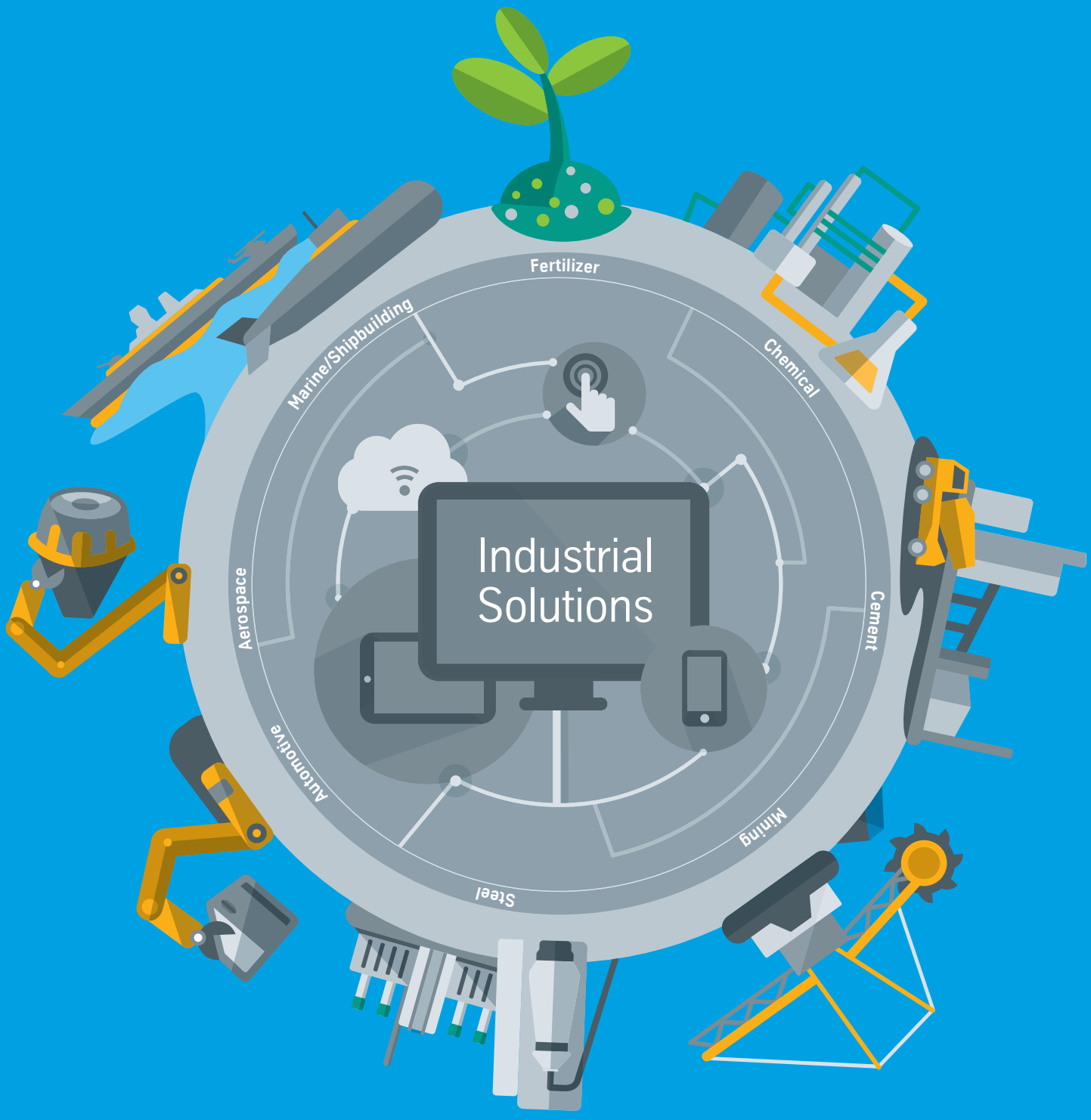
Industrial Solutions

Nitrates and sulphate fertilizers

Leading fertilizer know-how

thyssenkrupp



The power of true efficiency

The Business Area Industrial Solutions of thyssenkrupp is a world leader for planning, construction and service in the field of industrial plants and systems. Together with our customers we develop solutions at the highest level and deliver efficiency, reliability and sustainability throughout the entire life cycle. Our global network, with around 19,000 employees at 70 locations, enables us to provide turnkey solutions worldwide which set new benchmarks with their high productivity and particularly resource conserving technologies.

We are at home in many different industries. Along with chemical, fertilizer, coking, refinery, cement and other industrial plants, our portfolio also includes equipment for open-cast mining, ore processing and transshipment, as well as associated services. In the naval sector, we are a leading global system supplier for submarines and surface vessels. As an important system partner to our customers in the automotive, aerospace and battery industries, we optimize the value chain and improve performance.

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thyssenkrupp Industrial Solutions – The right choice

thyssenkrupp Industrial Solutions can look back on more than 80 years of experience in the fertilizer sector, during which time the company has engineered more than 360 plants.

With today's intensive agriculture, soil yields are very much a matter of choosing the right type of fertilizer. Selection criteria for the wide range of different grades now available include soil type, climate and crop type. This, in turn, reflects the need for high-quality fertilizer production. Choosing the right process is of the essence.

thyssenkrupp Industrial Solutions offers proven, competitive processes based on both proprietary and renowned licensed technologies, thus putting us in a position to offer a full range of plants for the production of single-component and mixed nitrogenous fertilizers.

The diagram on the right (Fig. 1) provides an overview of the principal fertilizer production routes, as well as the available processes and main licensors.

This brochure deals only with the key processes offered by thyssenkrupp Industrial Solutions for the production of mineral fertilizers.

For our urea, nitric acid and ammonia processes, please refer to our separate brochures.

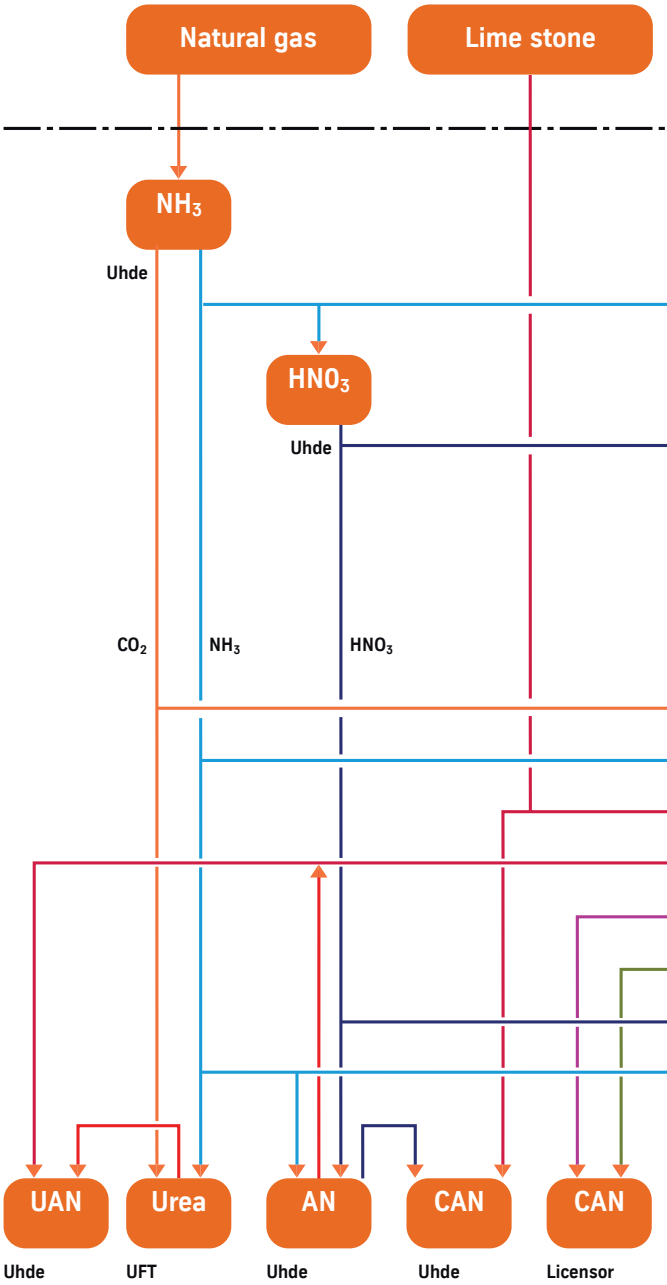
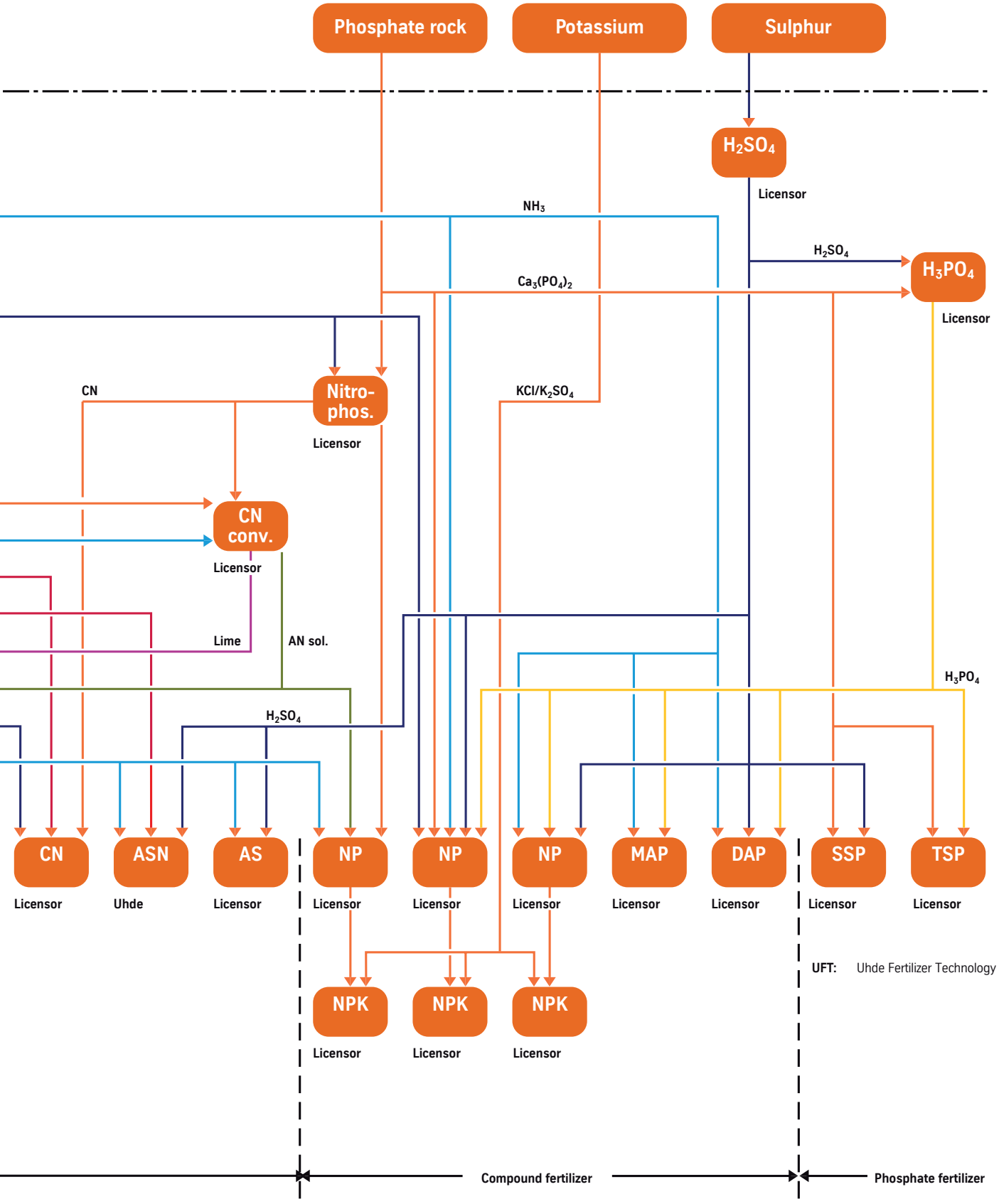


Fig. 1:
Uhde fertilizer processes


Phosphate rock
Potassium
Sulphur
H_2SO_4
Licensor
NH_3
H_2SO_4
H_3PO_4
$Ca_3(PO_4)_2$
Licensor
CN
Nitro-phos.
Licensor
KCl/K_2SO_4
CN conv.
Licensor
Lime
AN sol.
H_3PO_4
H_2SO_4
CN
ASN
AS
NP
NP
NP
MAP
DAP
SSP
TSP
Licensor
Uhde
Licensor
Licensor
Licensor
Licensor
Licensor
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NPK
NPK
NPK
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Licensor
Licensor
UFT: Uhde Fertilizer Technology
Compound fertilizer
Phosphate fertilizer

The Uhde ammonium nitrate neutralisation technology

Ammonium nitrate neutralisation is a proprietary Uhde process, designed for maximum reliability and safety. This well-proven technology is the basis of our nitrate fertilizer technology portfolio and has been used successfully by our customers in more than 40 commercial-scale plants for about 4 decades now.

Ammonium nitrate neutraliser

General

Ammonium nitrate is produced from gaseous ammonia and aqueous nitric acid in an exothermic reaction according to the following equation:

$$NH_3 + HNO_3 \rightarrow NH_4NO_3 - H_R$$

The heat of reaction is released into the circulating stream of AN solution, causing a temperature rise. Precise control of the reaction system parameters is essential for highly-efficient ammonium nitrate production. These parameters include in particular good mixing in of the reactants as well as reliable temperature and pH control. The Uhde technology comprises an external circulation loop, either forced or natural, and also a sophisticated reactant feed and mixing system for stable operating conditions.

thyssenkrupp Industrial Solutions offers two proprietary types of neutralisation processes for the production of ammonium nitrate solution:

Vacuum neutralisation and evaporation

This process is the most popular alternative because it involves the lowest investment costs. The reaction takes place in a slightly pressurised neutraliser to prevent the ammonium nitrate solution from boiling in the mixing and reaction sections thus minimising ammonia losses.

Subsequently, the solution is flashed into a vacuum through a restriction orifice adjacent to the vapour separator, thereby utilising the reaction heat for water evaporation. A solution concentration of 95 wt.% can be achieved with a preheated feed of 60 wt.% nitric acid. For control and safety reasons, however, the AN solution concentration is mostly limited to 92 wt.%.

The higher concentration necessary for further process steps, such as granulation (Section 4) or prilling (Section 5) is achieved by steam heating the solution under vacuum pressure. For optimum process control and stability, thyssenkrupp Industrial Solutions preferably applies a thermosyphon evaporation system. The scrubbed process vapours are used for feedstock preheating; surplus vapours are condensed.

Pressure neutralisation

In order to utilise the heat of reaction more efficiently, the process vapour system in this case operates above atmospheric pressure. thyssenkrupp Industrial Solutions offers two main pressure neutralisation alternatives for effective heat recovery:

a) The heat of reaction stored in the hot ammonium nitrate solution leaving the neutraliser is used direct for the final concentration stage. Even if a final concentration of 97wt.% is required, there is no need to import additional steam. (Fig. 3)

b) Heating steam is imported for final concentration of the ammonium nitrate solution, while part of the heat of reaction is utilised to generate low-pressure steam at approx. 5 bar abs. (Fig. 4)

In both cases the flash steam from the vapour separator at 2 - 4 bar abs is used for intermediate concentration of the weak ammonium nitrate solution. Again, the remaining process vapours are used for feedstock preheating; surplus vapours are condensed. Depending on how the vapour condensate is to be used, some or all of the vapours need to be scrubbed before condensation in a separate vapour scrubber.

Fig. 2:
Vacuum neutralisation
and evaporation

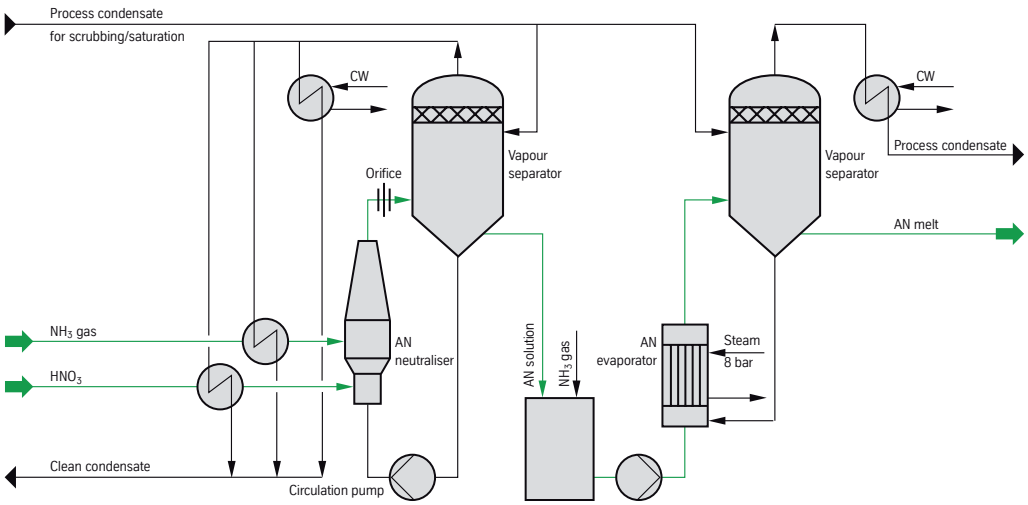


Fig. 3:
Pressure neutralisation
with direct heat recovery

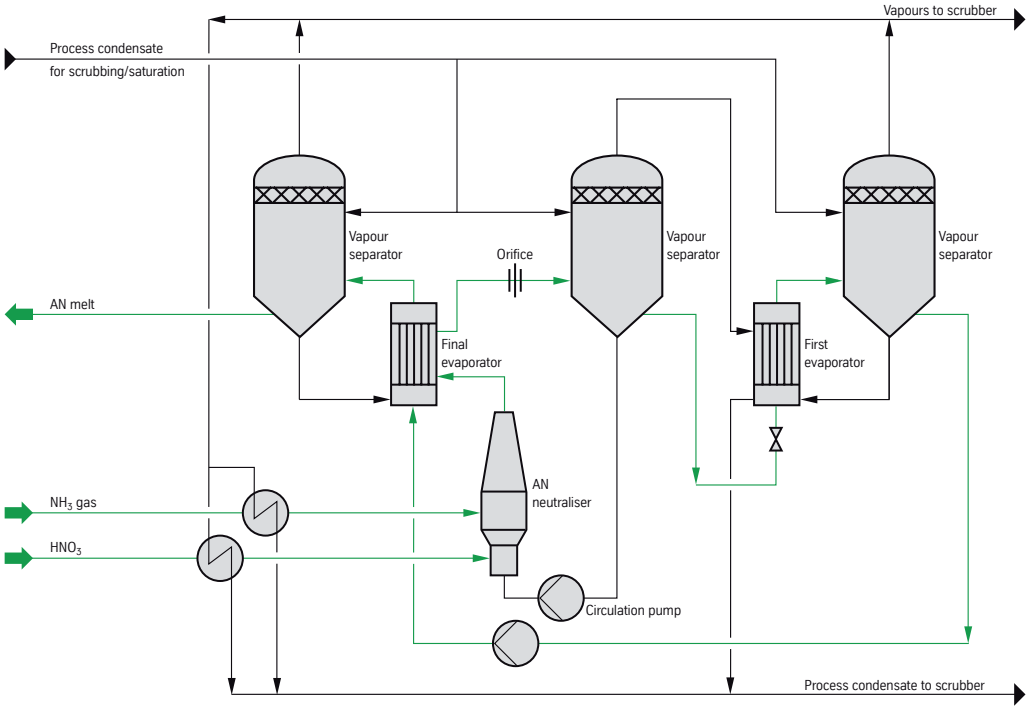
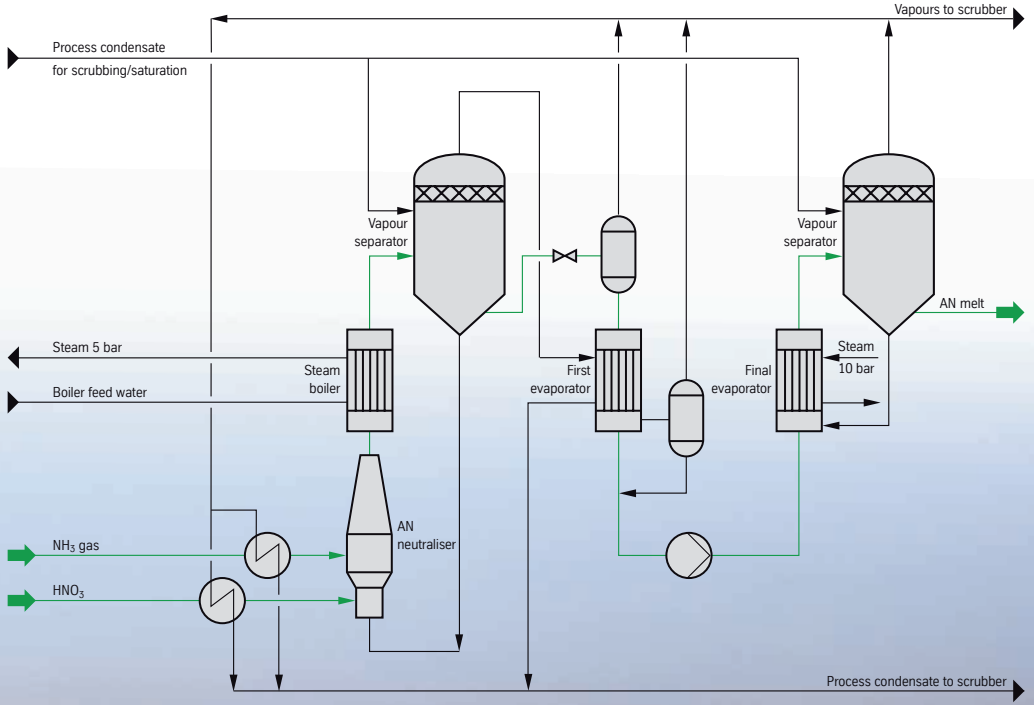


Fig. 4:
Pressure neutralisation
with clean steam production



thyssenkrupp Industrial Solutions can also offer a third-party ammonium nitrate process, for example the INCRO pipe reactor process, if required.

Pipe reactor process

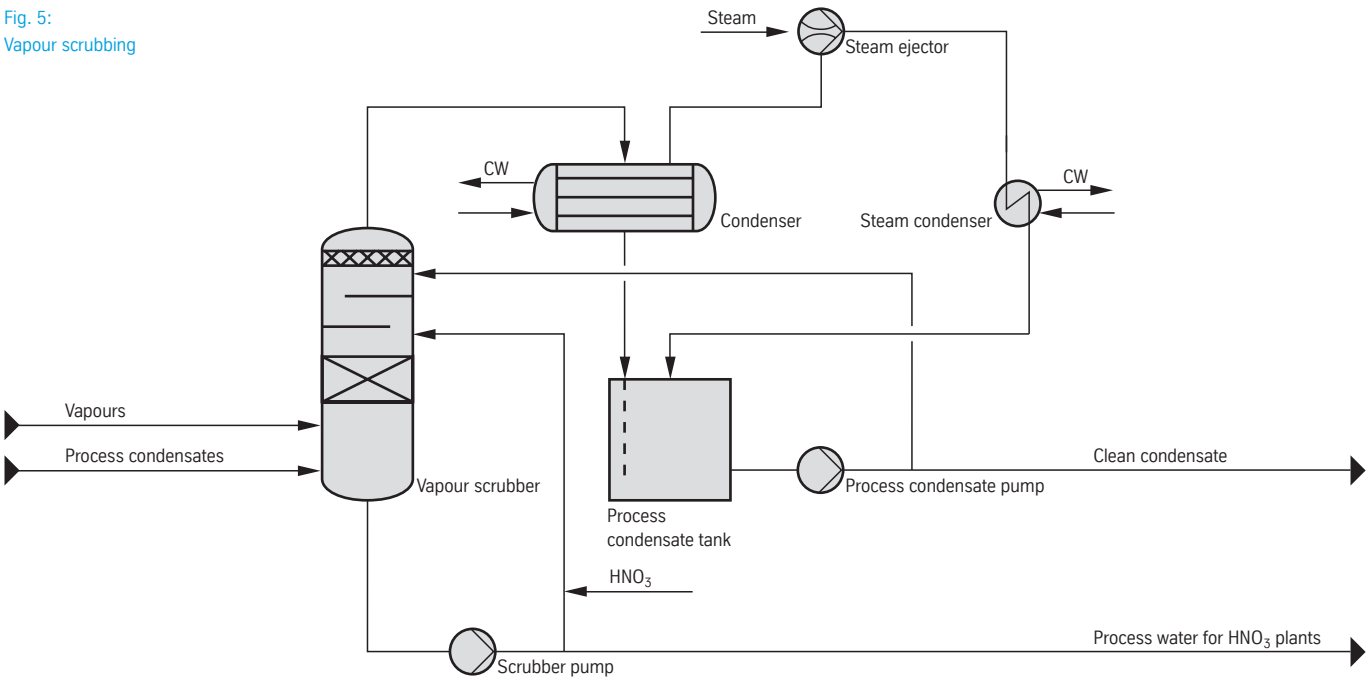
In this process ammonia and nitric acid are mixed in a long pipe equipped with internals. The heat of reaction immediately produces water vapours which cause a rapid flow through the pipe with a high degree of turbulence. In a downstream separator the flow is split into vapours and ammonium nitrate solution. The solution is fed into a flash tank before being pumped to the concentration stage while the vapours are scrubbed prior to further utilisation. The reaction process typically operates at pressures of 4 - 5 bar abs and the vapours can thus be used for further solution concentration and other heating purposes.

thyssenkrupp Industrial Solutions has already constructed and successfully commissioned licensed pipe reactor technology.

Vapour scrubbing

The vapours formed in the ammonium nitrate neutralisation and evaporation process are scrubbed either direct in the vapour separator or in a separate scrubbing column. Depending on the quality of the process vapours, a single or dual-stage scrubber is applied. The condensed overhead vapours from the scrubber can be used for various purposes, e.g. as scrubbing make-up water or as feed for a demineralised water plant. Contaminant levels in the clean condensate are as low as 15 ppm nitrogen. The sump concentrate can be used for nitric acid make-up.

Fig. 5:
Vapour scrubbing



Ammonium nitrate vacuum neutralisation and evaporation unit for Enaex S.A. in Mejillones, Chile.
Capacity: 1,060 t/day AN solution (92/96 wt.% AN)

Consumption figures (expected)			Vacuum neutralisation	Pressure neutralisation		Pugmill granulation
				2 bar abs with direct heat recovery	4 bar abs with clean steam production	AN 33.5 CAN 27
			Fig. 2	Fig. 3	Fig. 4	Fig. 6
Steam import	(4.5/10 bar a)	kg/t_{AN}	130	10	52	90
Steam export	(6.5/4.5 bar a)	kg/t_{AN}	–	–	240	
Cooling water		m^3/t_{AN}	31.0	22.5	3.8	5.0
Electrical energy		kWh/t_{AN}	2.0	3.8	4.8	29.0
Ammonia		kg/t_{AN}	213	213	213	
Nitric acid		kg/t_{AN}	789	789	789	

Remarks: Figures for 60 wt.% nitric acid feed, 96 wt.% AN product, cooling water at ΔT = 10°C, electrical energy without DCS, lighting, CR AirCon, limestone grinding, etc.

The Uhde pugmill granulation process

General

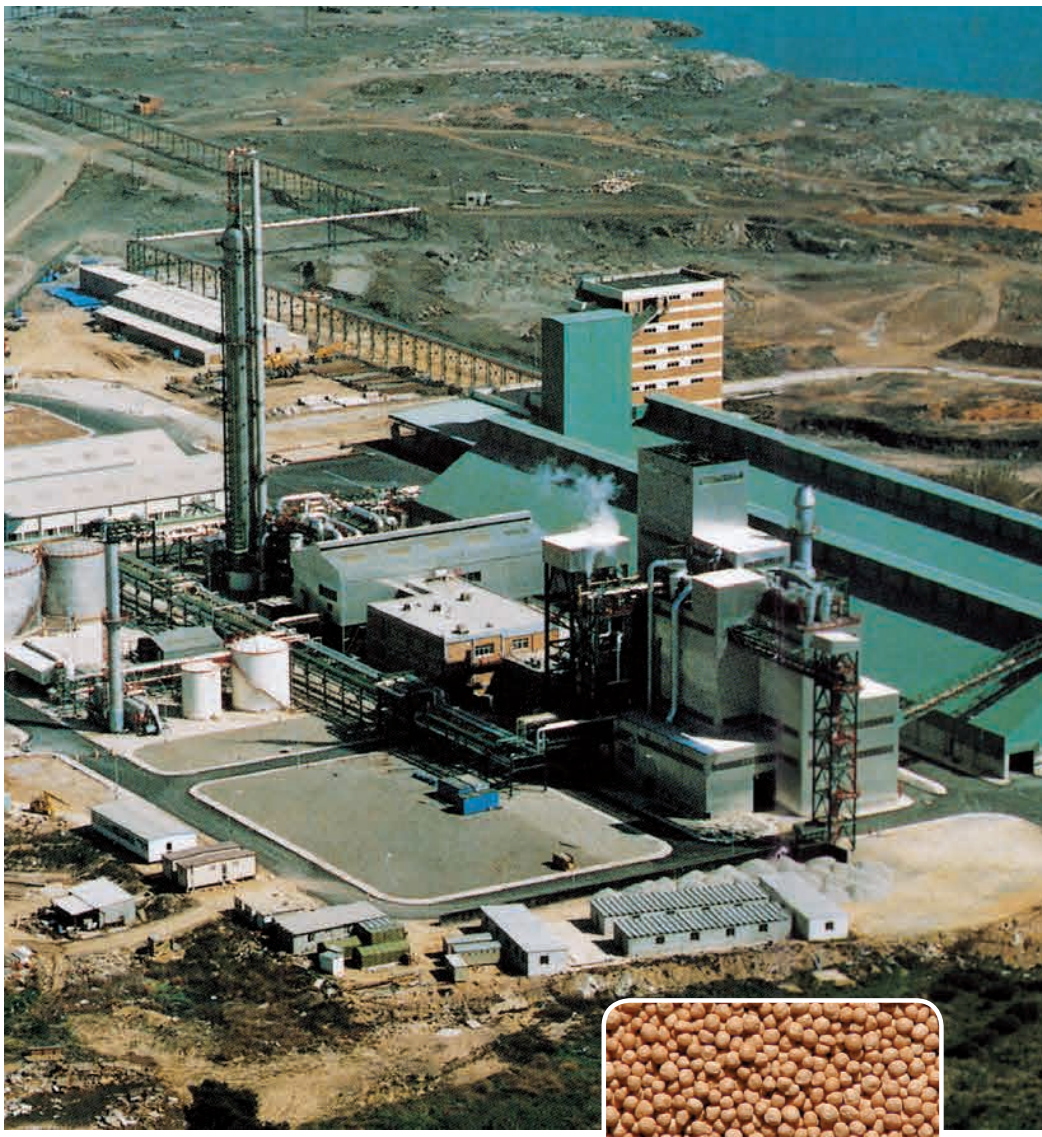
Today modern fertilizer plants supply granulated products. Prilling is becoming less common due to environmental constraints and increased product quality requirements.

In producing fertilizer from the various solid and liquid feed materials, the granulation unit must ensure that the resulting product meets market requirements with regard to its chemical and physical properties.

There are many different ways of producing granules, such as flaking, drum, pan or pugmill granulation and fluid-bed technology.

In the past, thyssenkrupp Industrial Solutions has built granulation plants for all common fertilizer grades from straight N fertilizer to NP(K) and P(K) fertilizers. thyssenkrupp Industrial Solutions has a wealth of experience in the design and operation of granulation plants and is in a position to build plants based on all modern granulation processes.

The most common granulation process used in nitrate fertilizer plants built by thyssenkrupp Industrial Solutions is the proprietary Uhde pugmill granulation process.

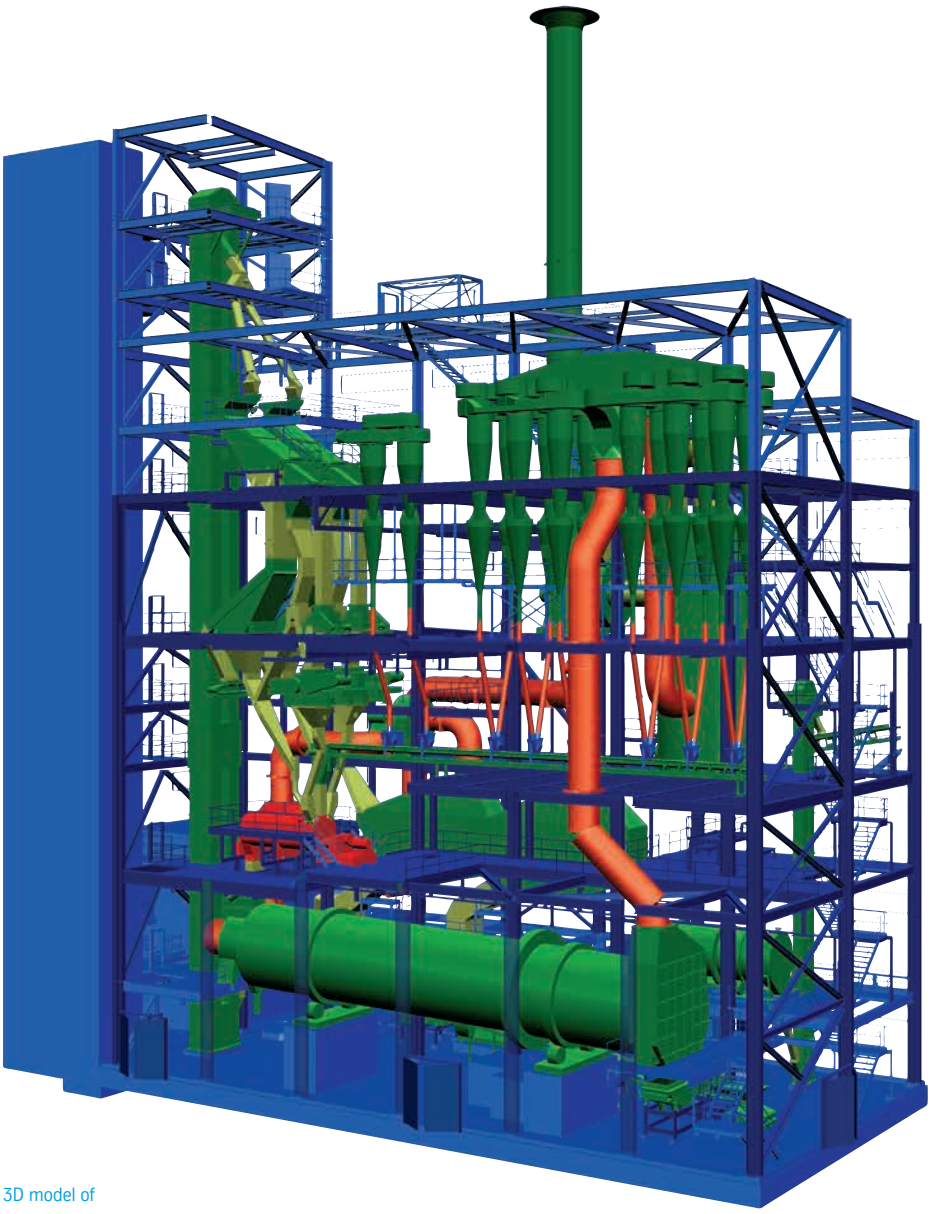


AN/CAN pugmill granulation plant,
Fertiberia S.A. (formerly Enfersa) in Sagunto/Spain
Capacity: 1,100/1,400 tpd (33.5 wt.%/26 wt.% N)

AN granules

CAN granules

Pugmill granulation unit for ANWIL S.A. in Wloclawek, Poland.
Capacities: 1,200 t/day AN granules and
1,500 t/day CAN granules



3D model of
the Uhde pugmill granulation

The Uhde pugmill granulation process

The core component of thyssenkrupp Industrial Solutions' own granulation process is a pugmill granulator. A pugmill or blunger is a horizontal mixing and agglomeration device. Its design is based on a horizontal U-type trough with dual shafts and paddles extending the length of the trough. The rotation of the pitched paddles moves the product from the bottom of the trough up through the centre. As a result of the speed at which the paddles rotate, the granules are fluidised in the upper part of the granulator.

All solid feeds (e.g. filler or additives) and the recycle material are added at the front of the pugmill to ensure sufficient mixing before the liquids are added. The liquid feed (e.g. ammonium nitrate melt) is distributed over the fluidised material using a proprietary distributor.

In the granulator the material is built up to size through agglomeration and layering. The hot, moist granules leaving the granulator drop through a chute into the rotary drying drum. In the drying drum the granules are dried by means of hot air. The dried granules are then screened into oversize, on-size and undersize fractions by double-deck or single-deck screens. The undersize fraction is returned to the granulator immediately; the oversize fraction is crushed beforehand.

The on-size, or product, fraction is cooled in a fluidised-bed cooler with conditioned air to a suitable storage temperature.

The cooled product is then passed to a conditioning unit where surface-active substances are applied to improve the handling and/or transport properties (e.g. anti caking, dusting, etc.).

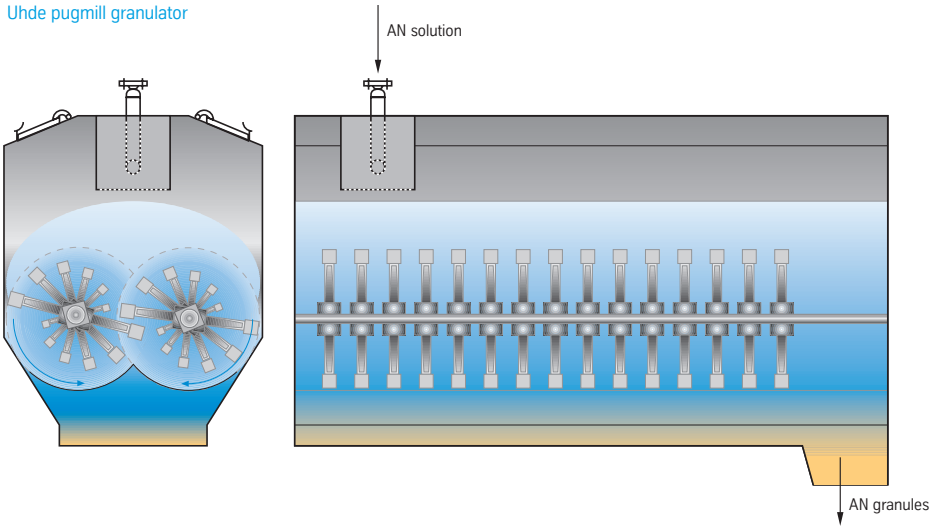
The waste air of the fluidised-bed cooler is used to dry the product, thus considerably reducing the amount of waste air to be treated. It also reduces power consumption as the products can be dried autothermally or with a significantly reduced heat input by an air heater installed upstream of the drying drum.

Most of the dust in the waste air from the drying drum is removed by cyclones and returned to the granulator. After passing through the cyclones, the air still contains dust and ammonia, which have to be removed in order to comply with environmental regulations.

The waste air from the drying drum and the air from the dedusting system are therefore sent to a wet scrubber. Here, the dust is largely removed from the air by close contact with the scrubbing solution while the ammonia reacts with the nitric acid contained therein.

The bleed from the scrubber is returned to the evaporation system. Therefore, no liquid effluents are produced during normal operation.

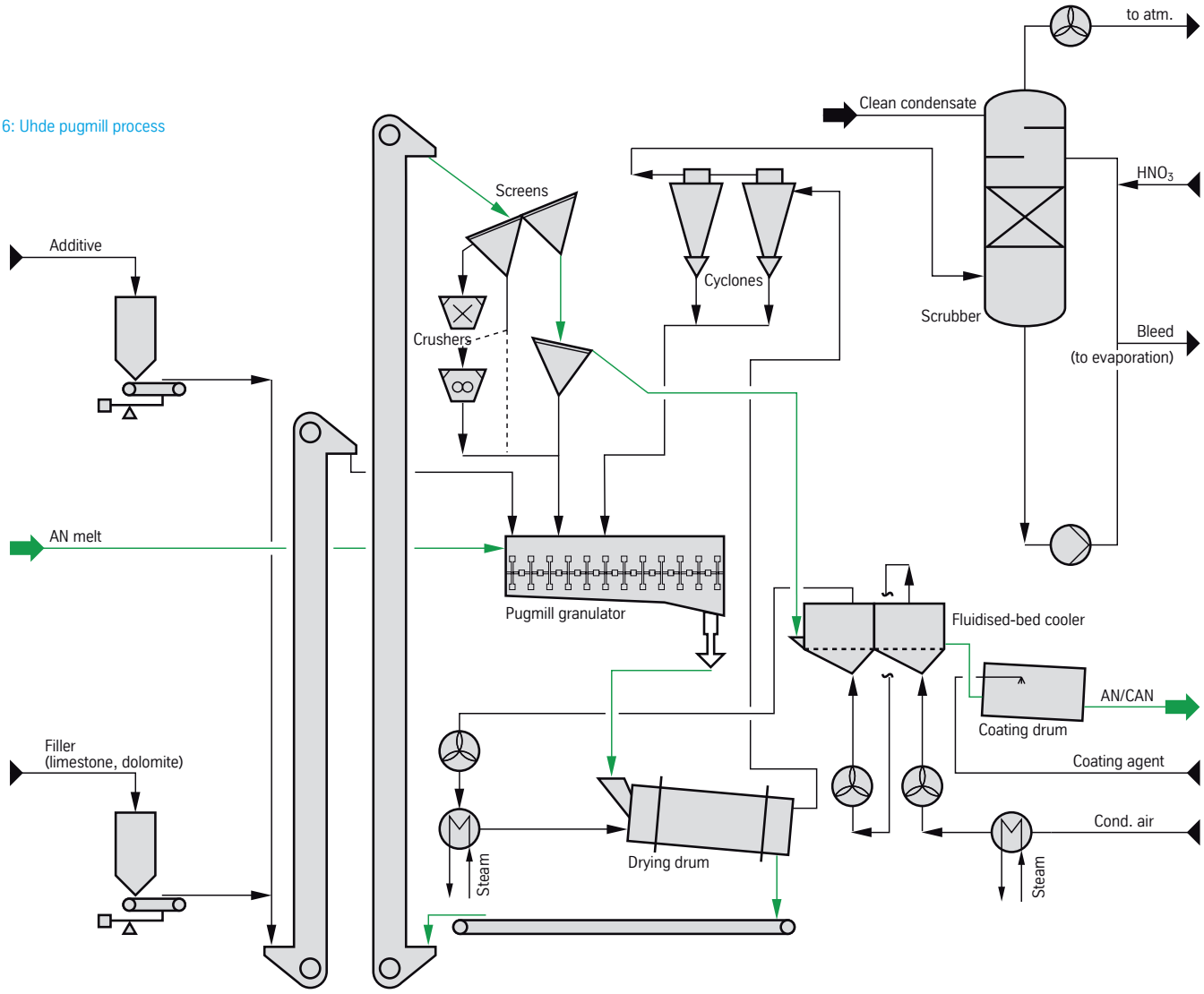
Uhde pugmill granulator



Key features

- Flexible with regard to capacity
- Flexible with regard to production of different products e.g. AN, ASN, CAN
- Easy addition of supplementary nutrients (S, Mg, etc.)
- Capacity – installed single-line capacity from 200 to 2,000 t/day
- Emissions below BAT levels
- No liquid effluents
- Power consumption below 30 kWh/t (depending on product)
- Low air flow

Fig. 6: Uhde pugmill process



Prilling for low-density ammonium nitrate

Although prilling plants for fertilizer-grade ammonium nitrate have decreased in importance compared to granulation processes, prilling is still the state-of-the-art process for low-density ammonium nitrate. thyssenkrupp Industrial Solutions offers a proprietary technology as well as qualified engineering services for licensed processes.

Low-density ammonium nitrate (LDAN) is used as an effective and cost-efficient mining explosive, mainly as a mixture with fuel oil (ANFO) or in emulsion-type explosives. The high porosity of the LDAN allows good oil absorption, which is necessary for an optimal blasting energy yield. If no additives are used, chemically pure ammonium nitrate can be produced, e.g. as feedstock for medical purposes (nitrous oxide).

Main characteristics of the final LDAN prills:

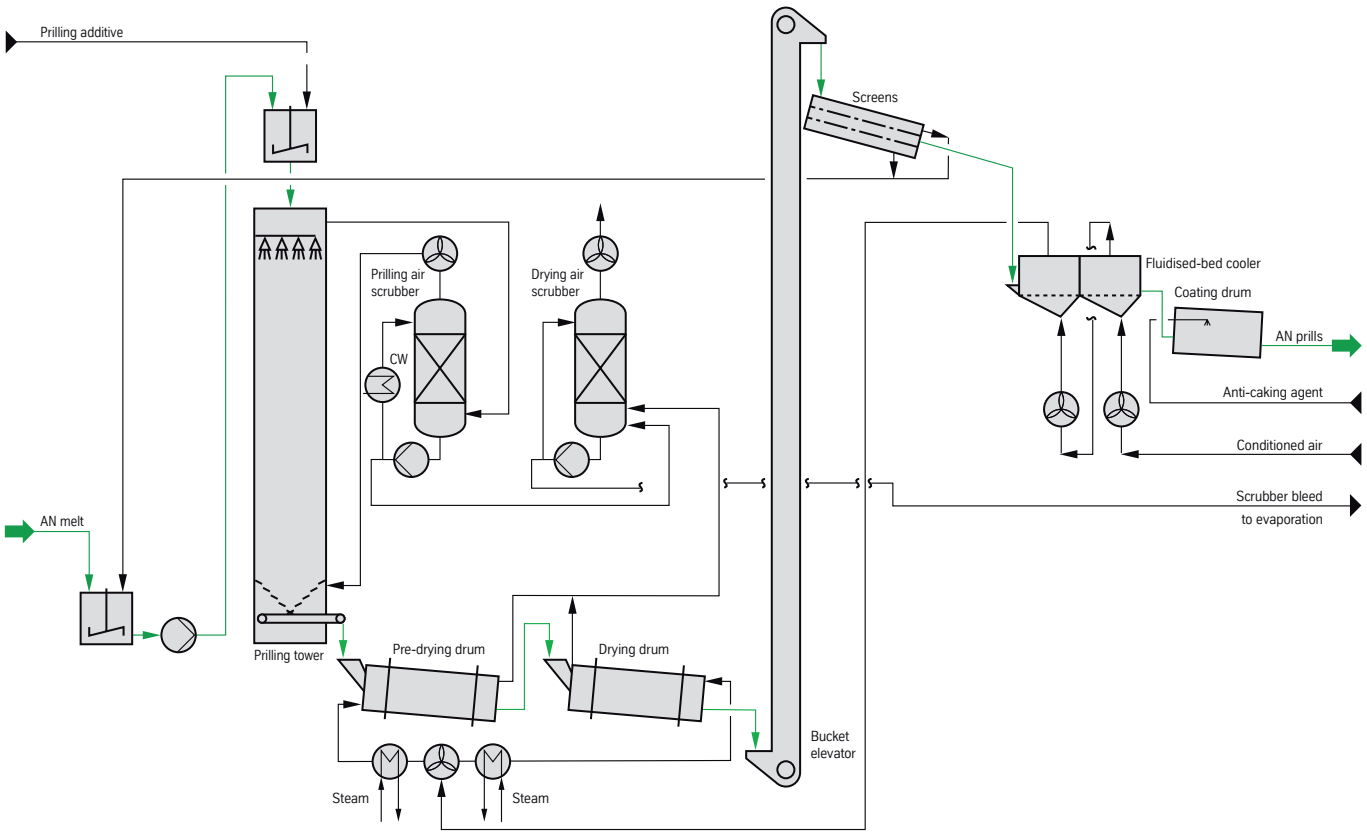
- Uniform spherical shape
- Nitrogen content > 34.7 wt.%
- Water content < 0.1 wt.%
- Grain size 1 - 2 mm
- Fuel absorption > 6 wt.% (adjustable)
- Free-flowing
- Good thermal resistance to hot climates

For the production of low-density prills the ammonium nitrate melt is pumped to the prilling tower top and mixed with a prilling additive. From here the melt is sprayed in droplets which crystallise in a countercurrent stream of cool air.

The prills are then sequentially dried in two rotating drums, screened, cooled in a fluid-bed cooler and coated with an anti-caking agent. Off-spec material is redissolved and recycled to the process. All air used in the process is scrubbed to meet BAT emission levels. By reusing the cooling air in the drying drums, energy consumption and waste air flow are significantly reduced.

thyssenkrupp Industrial Solutions has designed LDAN prilling plants with single-line operating capacities of 1,250 t/day and engineered licensed processes of up to 1,060 t/day.

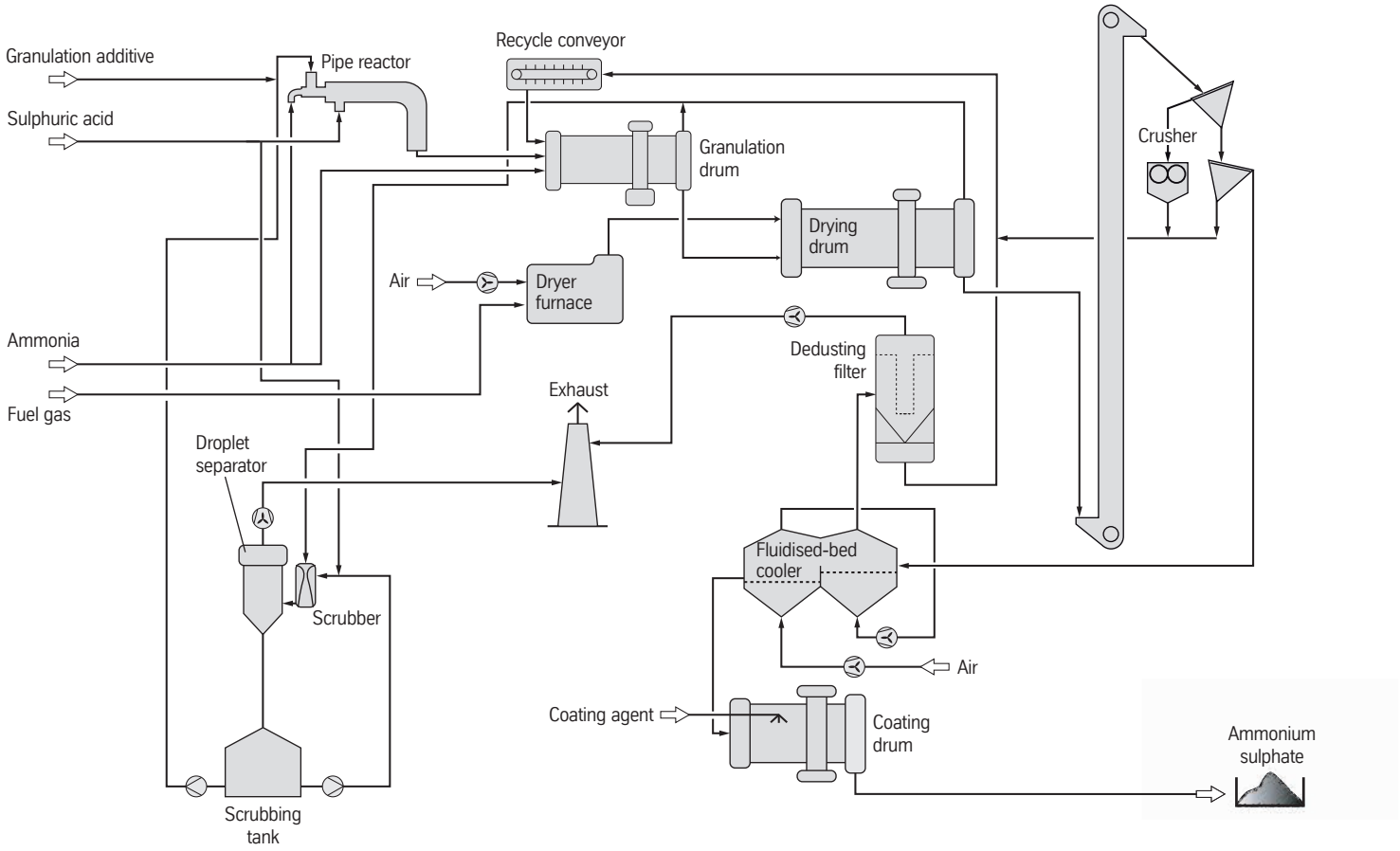
Fig. 8:
Uhde LDAN prilling process



Ammonium nitrate prilling unit for
Queensland Nitrates Pty Ltd., Australia.
Capacity: 400 t/day AN prills (technical grade)

Ammonium nitrate prilling complex for
VINACOMIN-Mining Chemical Industry
Holding Corp. Ltd., Vietnam.
Capacity: 625 t/day AN prills (technical grade)

Ammonium sulphate – AS



Strong Granules

The rotary drum granulation delivers a smooth granulate with a hardness of >35 N.

Low Energy Consumption

If sulphuric acid is directly neutralized with ammonia, a high energy yield reduces the necessary energy supply for water evaporation.

Process description

Ammonium sulphate is obtained from the reaction of gaseous ammonia with concentrated sulphuric acid in a reactor. Ammonium sulphate has a low solubility in water (about 40 - 50 % max.). Therefore, additional water must be fed into the reactor to obtain a flowing solution/slurry which is then delivered to a rotary drum for granulation. The solution still contains sulphuric acid that is neutralized with ammonia within the rotary drum granulator.

The recycled fines and the small shaped material are growing along the length of the rotary drum until they reach the desired size. The water from AS solution is vaporized using the heat of reaction.

UAN solution

Fertilizer complex for CF Industries Inc. in Louisiana, USA including a 2,000 t/day urea plant, a 870 t/day nitric acid plant, a 1,105 t/day AN plant and a 2,450 t/day UAN solutio plant.

UAN

The use of liquid fertilizers is a common practice, especially in North America. A fertilizer with excellent physical properties is UAN solution, which is a mixture of ammonium nitrate, urea and water. Standard solutions contain 28, 30 and 32% nitrogen, respectively, but can also be enriched with soluble plant nutrients, such as sulphur, boron and calcium compounds. A typical composition of UAN solution with 32% N is

AN : Urea : H_2O = 45 : 35 : 20%

As UAN solution is a liquid with a low viscosity, it can easily be applied by spraying without the need for additional irrigation. Depending on its composition, the salting-out temperature of the solution can be well below zero degrees centigrade and transport and storage are thus simple even in cold climates.

thyssenkrupp Industrial Solutions has designed UAN plants based on two process alternatives:

a) UAN solution on the basis of ammonium nitrate neutralisation

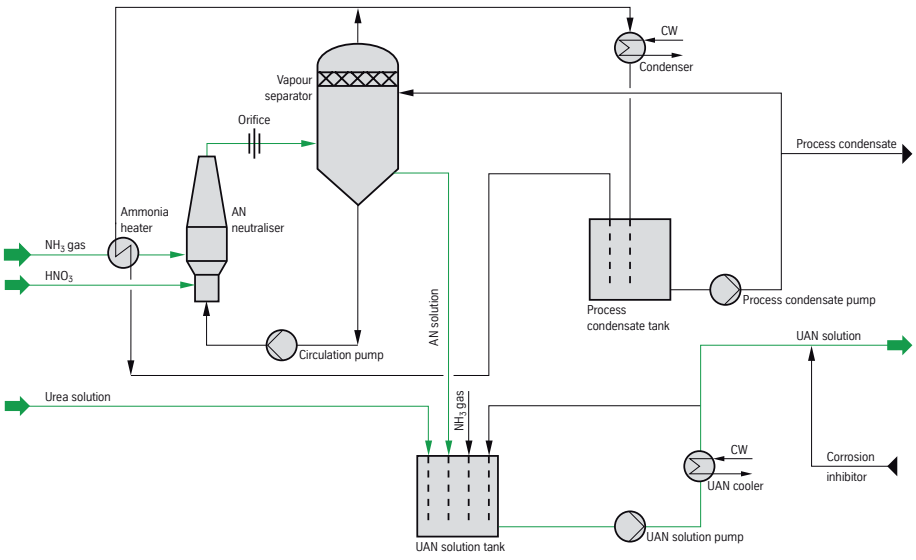
In this process alternative ammonium nitrate is produced as described in Section 3. Urea solution and water are mixed with the AN solution in a special UAN mixing unit to obtain the required nitrogen content and adjusted to an alkaline pH. After cooling and the addition of a corrosion inhibitor, the final UAN solution can easily be stored and handled.

b) Neutralisation of urea off-gas

When implementing a once-through urea synthesis, the ammonia-rich off-gas can be used to drive the ammonium nitrate neutralisation reaction. Due to the high CO_2 content in the off-gas, the neutralisation reaction is performed in a natural circulation loop, followed by the UAN preparation steps described before. In order to minimise the ammonia losses in the vent gas, a sophisticated scrubbing system is installed, reducing the losses to 0.013 kg_{AN}/t_{AN}.

Contaminant levels in the process condensate used as make-up water for a nitric acid plant are as low as 300 ppm AN and 100 ppm HNO_3.

Fig. 11: UAN solution process with ammonia gas



UAN solution plant for CF Industries Inc. in Louisiana, USA

UAN off-gas vent scrubber

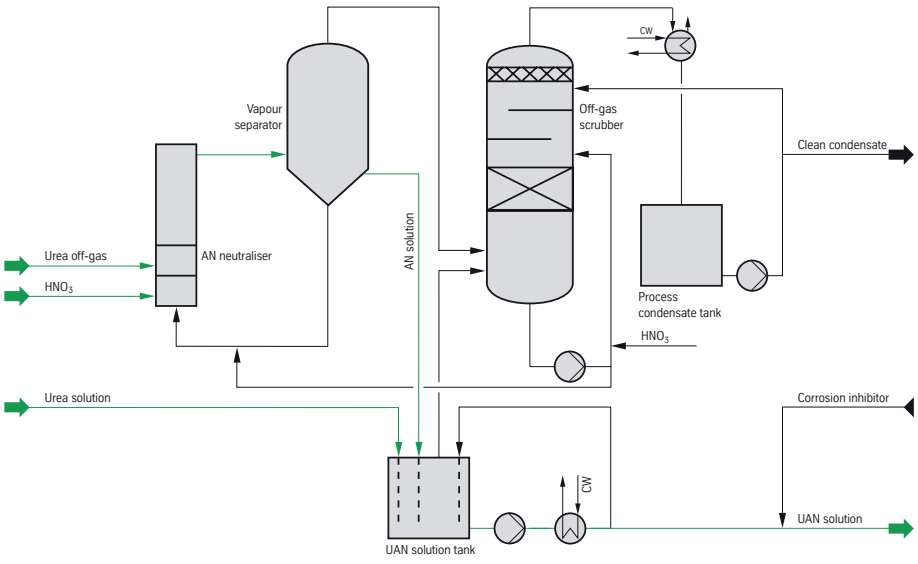


Fig. 12: UAN solution process with urea off-gas

Industrial Solutions
Fertilizer and Syngas Technologies

thyssenkrupp Industrial Solutions AG
Friedrich-Uhde-Straße 15
44141 Dortmund
Germany
P: +49 231 547 0
F: +49 231 547 10
www.thyssenkrupp-industrial-solutions.com

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