

Industrial Solutions

Nitrates for fertilizers and technical applications

Market-leading fertilizer
know-how



thyssenkrupp



Why we are the right choice

In today's business environment, the fertilizer producer with the most efficiently operating plant, with the lowest production cost and the highest reliability, with the best quality of his product and with the highest flexibility to cope with his customers' needs is having the decisive competitive advantage. Choosing the right production technology is essential. We can help you to choose wisely, provide you with the right processes and will deliver your plant.



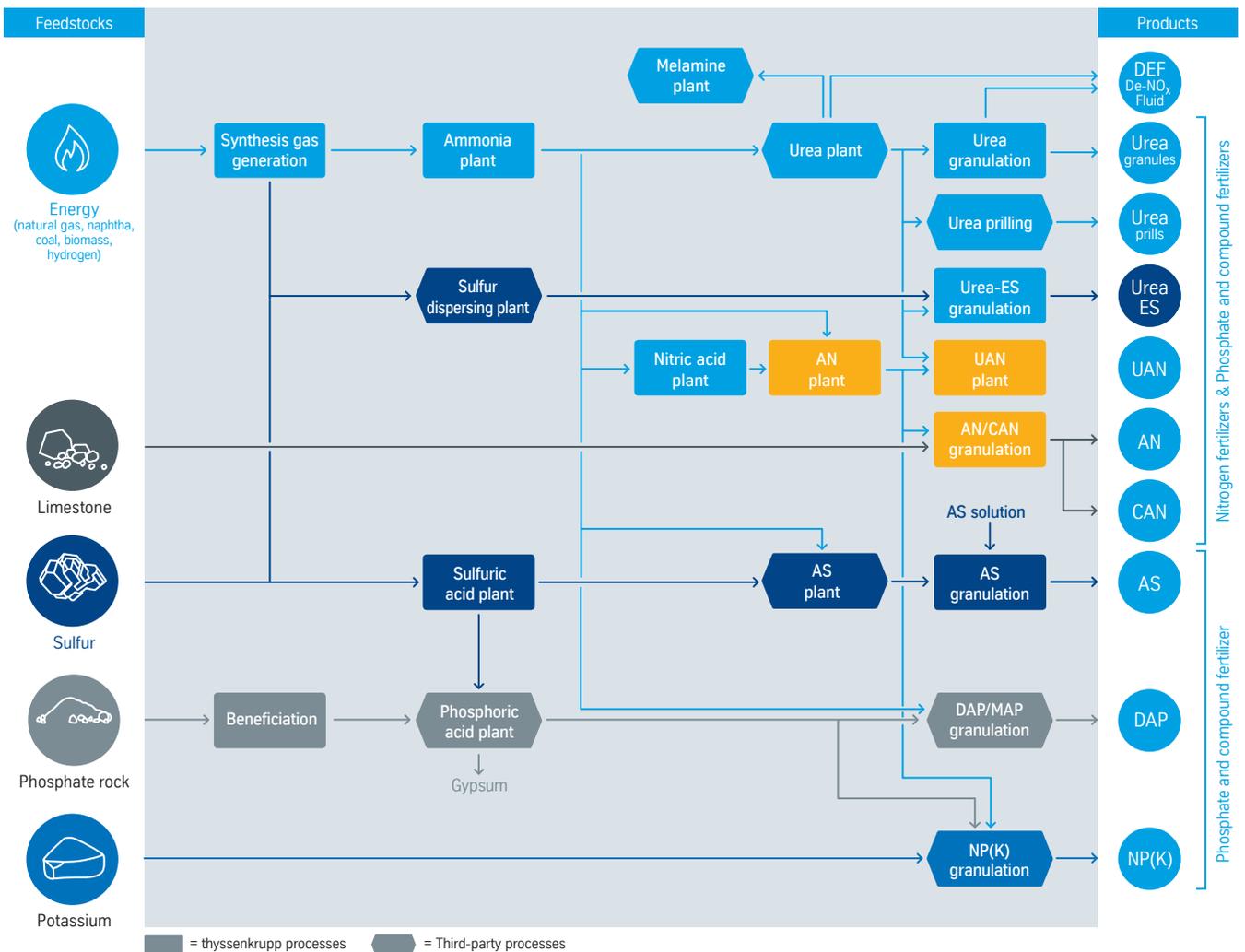
At thyssenkrupp Industrial Solutions we can point to over 80 years of experience in the fertilizer sector and more than 360 plants we have engineered. As we offer proven, competitive processes based on both proprietary and renowned licensed technologies, we can deliver a full range of plants for the production of single-component and mixed nitrogenous fertilizers. The diagram below provides an overview of the principal fertilizer production routes, as well as the available processes and main licensors.

This brochure only deals with the key processes we offer for the production of nitrate fertilizers and technical applications. For our urea, nitric acid and ammonia processes please refer to the separate brochures.



Digital analyzing tools allow state-of-the-art monitoring and process management

thyssenkrupp Industrial Solutions offers you the complete process chain for the production of different fertilizers:



uhde® ammonium nitrate neutralization

Maximizing reliability and safety

Ammonium nitrate neutralization is a proprietary uhde® process designed for maximum reliability and safety. This well-proven technology forms the basis of our nitrate fertilizer technology portfolio. For more than four decades it has been successfully used by customers in over 40 commercial-scale plants with single-train capacities of 225-1,960 mtpd.

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



The heat of reaction is released into the circulating stream of ammonium nitrate (AN) solution, causing a rise in temperature. Precise control of the reaction system parameters is essential for highly efficient AN production. These parameters include, in particular, well mixed-in reactants and reliable temperature and pH control. The uhde® technology comprises an external circulation loop, either forced or natural, as well as a sophisticated reactant feed and mixing system for stable operating conditions. We offer two proprietary types of neutralization processes for the production of AN solution.

Vacuum neutralization

This process is the most popular alternative because it involves the lowest investment costs. The reaction takes place in a slightly pressurized neutralizer to prevent the AN solution from boiling in the mixing and reaction sections, thus minimizing ammonia losses. Subsequently, the solution is flashed into a vacuum through a restriction orifice adjacent to the vapor separator, thereby utilizing 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.%.

Vapor scrubbing

The vapors formed in the ammonium nitrate neutralization and evaporation process are scrubbed either in the vapor separator direct or in a separate scrubbing column. Depending on the quality

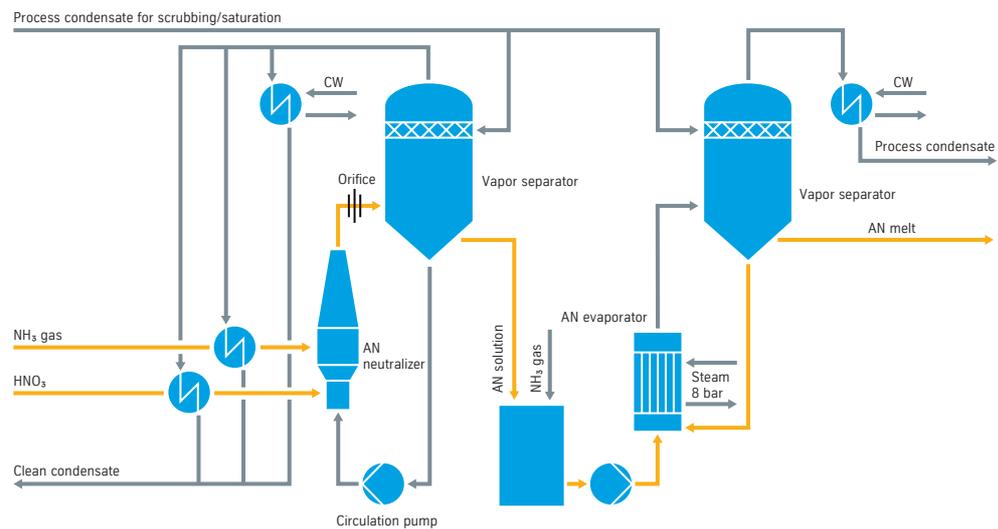


Ammonium nitrate neutralizer

of the process vapors, a single or dual-stage scrubber is applied. The scrubbed process vapors are used for feedstock preheating, while surplus vapors are condensed. The higher concentration necessary for additional process steps, such as granulation (pp. 6-7) or prilling (pp. 10-11) is achieved by steam-heating the solution under vacuum pressure. For optimum process control and stability we use a thermosiphon or falling film evaporation system.

Pressure neutralization

In order to utilize the heat of reaction more efficiently, the process vapor system operates in this case above atmospheric pressure. We offer two main pressure neutralization alternatives for effective heat recovery.



uhde® vacuum neutralization and evaporation process

How you benefit:

- ⌚ High AN concentration downstream of the neutralization unit (up to 93%): Other technologies need additional concentration steps.
- ⌚ Production of very clean process condensate (e.g. 15 ppmw nitrogen) compared to several g/l in other technologies: The clean process condensate can be used as make-up water in the absorption tower of the nitric acid plant, in the cooling water system or in the demineralized water system. Other technologies need additional water treatment steps.
- ⌚ Very low reaction temperature due to high circulation rate and low pressure (145°C compared to >180°C in other technologies) – very important from a safety point of view
- ⌚ High flexibility in terms of turndown: This technology can be operated at around 40-110% of capacity just by changing the set points of control loops. Other technologies need to change hardware (e.g. inserts) to adapt the capacity in a wide range with corresponding off-time.
- ⌚ No wear & tear parts for excellent availability: The plant can be operated without interruption for up to a year.
- ⌚ Optimized plant safety through independent control and shut-down systems

uhde® pugmill granulation

All market requirements met

Modern fertilizer plants produce granulated products, with prilling becoming less common due to environmental constraints and increased product quality requirements. The uhde® pugmill granulation process ensures that the resulting product meets all market requirements with regard to its chemical and physical properties.

There are many different ways of producing granules, e.g. flaking, drum, pan, fluid-bed or pugmill granulation. Having constructed granulation plants for all common fertilizer grades from straight N fertilizer to NP(K) and P(K) fertilizers, we have a wealth of experience in the design and operation of granulation plants and can build plants based on all modern granulation processes, including our proprietary uhde® pugmill granulation process.

How this process works

The core component of our uhde® pugmill granulation process is the patented pugmill granulator. A pugmill is a horizontal mixing and agglomeration device designed like a horizontal U-type trough with dual shafts and paddles. The rotation of the paddles fluidizes the granules in the upper part of the granulator. All solid feeds (e.g. filler or additives) and the recycled material are added at the front of the granulator to ensure sufficient mixing before the liquids are added. The liquid feed (e.g. ammonium nitrate melt) is distributed over the fluidized material using a proprietary distributor.

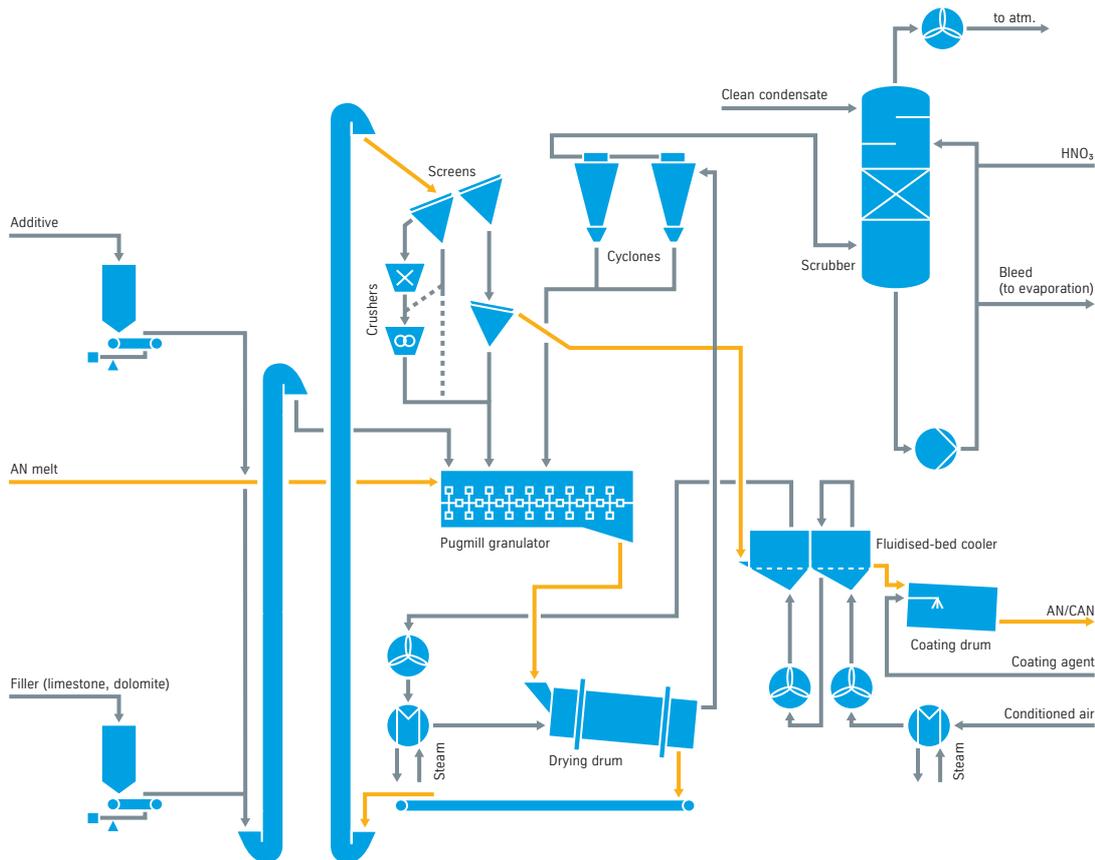
In the granulator the material is built up to size through agglomeration and layering. The hot, moist granules leaving the granulator drop through a chute into the rotary drying drum where they are

dried by hot air. The dried granules are then screened into oversized, on-size and undersized fractions by double-deck or single-deck screens. The undersized and oversized fractions are returned to the granulator. The on-size fraction is cooled in a fluid-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 air leaving the fluid-bed cooler is used to dry the product, thus considerably reducing the amount of waste air to be treated. This also reduces power consumption as the products can be dried auto-thermally or with a much reduced heat input by an air heater installed upstream of the drying drum. Most of the dust in the air from the drying drum is removed by cyclones and returned to the granulator. The waste air from the drying drum and the air from the de-dusting system are sent to a wet scrubber where the residual dust and ammonia are removed to comply with environmental regulations. As the bleed from the scrubber is returned to the evaporation system, no liquid effluents are produced during normal operations.



AN/CAN pugmill granulation plant, Nitrogenművek, Hungary
Capacity: 1,960/1,550 mtpd (27 wt.%/33.5 wt.%)



uhde® pugmill granulation process



AN granules



CAN granules

How you benefit:

- ⌚ Flexible capacities; installed single-line capacity 200-2,000 mtpd
- ⌚ Flexible production of different products, e.g. AN, CAN, CAN-S
- ⌚ Easy addition of supplementary nutrients, e.g. S, Mg. etc.
- ⌚ Emissions below BAT levels
- ⌚ No liquid effluents
- ⌚ Power consumption below 30 kWh/t (depending on product)
- ⌚ Low air flow

uhde® UAN solution

Clean processes with highest availability

The uhde® AN neutralization generates as side stream process condensate with a contamination well below 15ppmw which can be easily used as make-up water in downstream processes.

UAN solution, a mixture of ammonium nitrate, urea and water, allows the composition of liquid fertilizers with excellent properties. Due to its' low viscosity, it can easily be applied by spraying with no need for additional irrigation. Depending on its composition, the salting-out temperature can be well below 0°C so that transport and storage are no trouble, even in cold climates. Thus these fertilizers have gained excellent market positions, especially in North America.

Standard solutions contain 28%, 30% or 32% nitrogen but can also be enriched with soluble plant nutrients, such as sulfur, boron and calcium compounds. A typical composition of UAN solution with 32% N is:

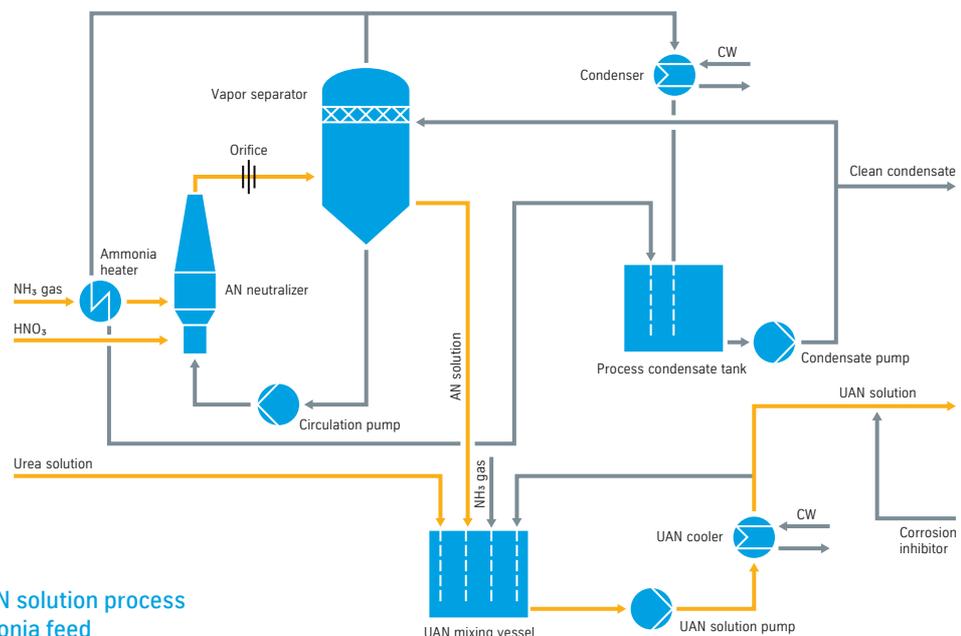
AN : Urea : H₂O = 45 : 35 : 20%

With two process alternatives in our portfolio we have designed UAN plants in capacity ranges from 560-4,300 mtpd, each in a single train.

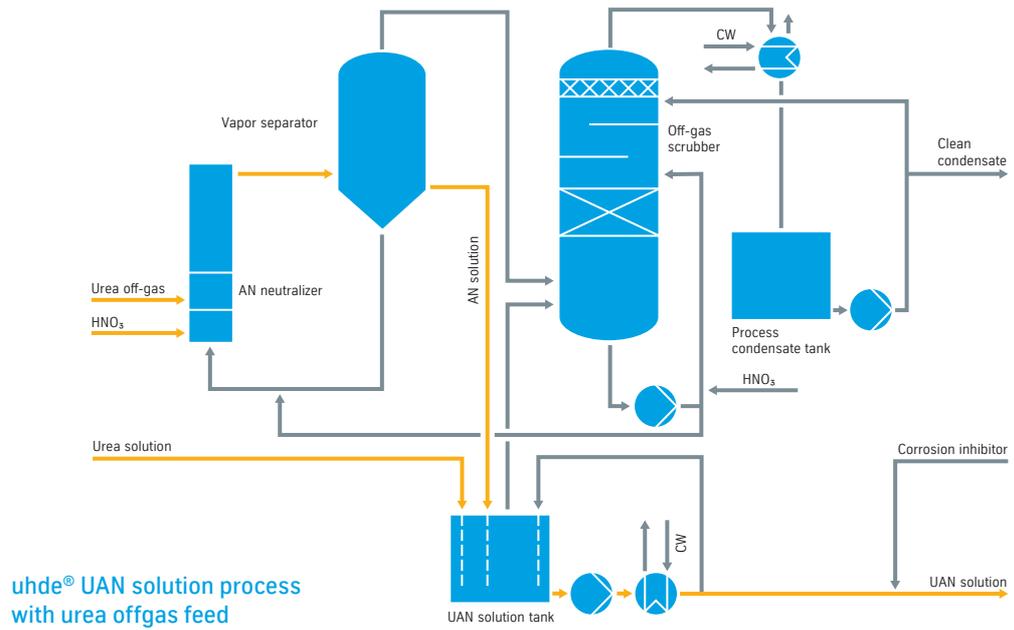
UAN solution based on ammonium nitrate neutralization

Ammonium nitrate (AN) is produced in the uhde® ammonium nitrate neutralization process (see pages 4-5). The AN solution is then mixed with Urea solution and water in a special UAN mixing unit to obtain the required nitrogen content and adjusted to an alkaline pH. After cooling and addition of a corrosion inhibitor, the final UAN solution can be easily stored and handled. The contaminant level in the process condensate is normally below 15 ppmw nitrogen.

uhde® UAN solution plant for CF Industries Inc., Louisiana, USA



uhde® UAN solution process
with ammonia feed



UAN off-gas vent scrubber

UAN solution based on neutralization of urea off-gas

When implementing a once-through urea synthesis, the ammonia-rich off-gas can be used to drive the ammonium nitrate neutralization reaction. Due to the high CO₂ content of the off-gas, the neutralization reaction is performed in a natural circulation loop, followed by the UAN preparation steps described above. A sophisticated scrubbing system is installed to reduce ammonia losses in the vent gas to 0.013 kgAN/tAN

uhde® low-density ammonium nitrate prilling

Effective and cost-efficient

For technical ammonium nitrate, prilling is still the state-of-the-art process for low-density product.

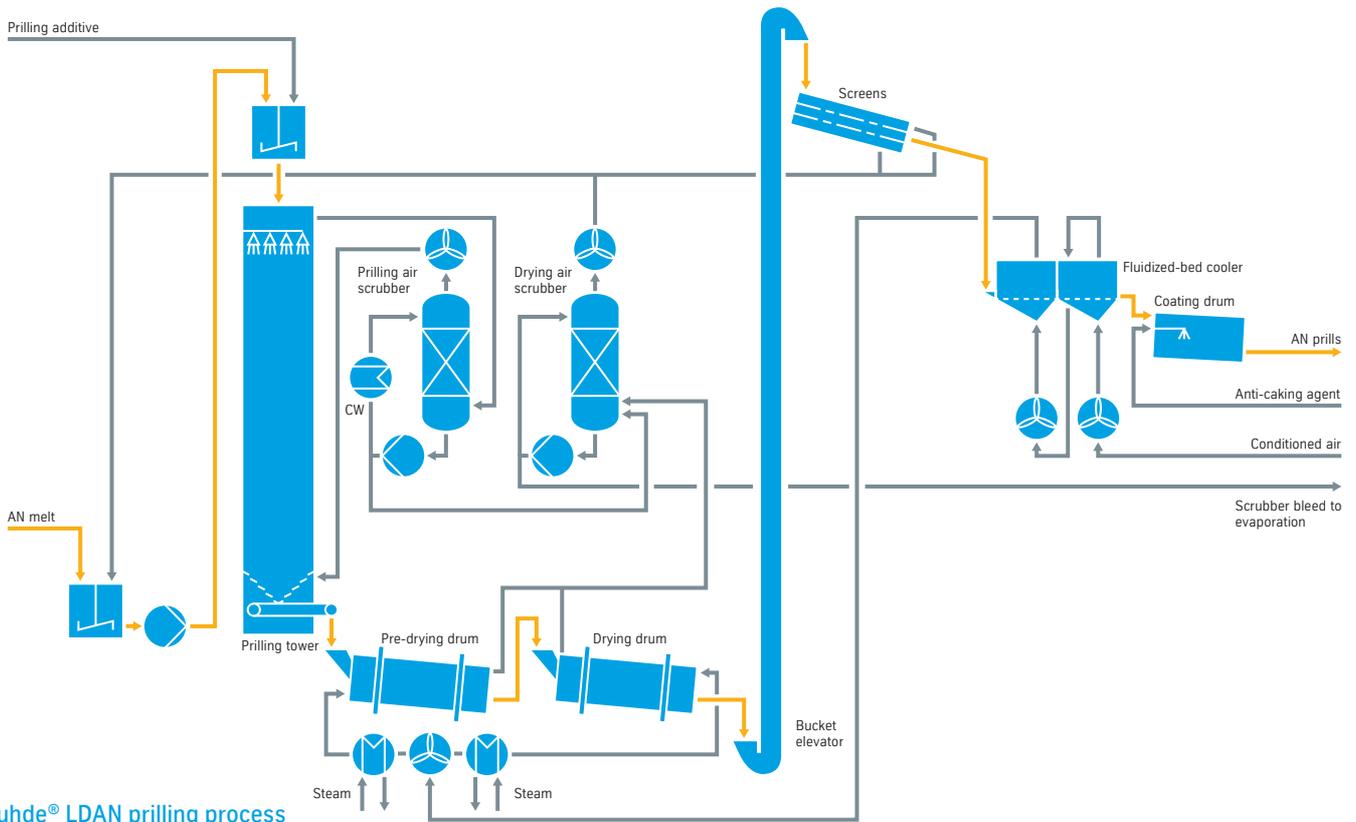
Low-density ammonium nitrate (LDAN) is used as an effective and cost-efficient mining explosive, mainly mixed with fuel oil (ANFO) or in emulsion-type explosives. The high porosity of the LDAN allows good oil absorption, which is necessary for an optimal blasting energy yield. If no additives are used,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

For the production of low-density prills the ammonium nitrate melt is pumped to the top of the prilling tower and mixed with a prilling additive. From here the melt is sprayed in droplets that crystallize in a counter-current 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 returned to the process. All the air used in the process is scrubbed to meet BAT emission levels. By reusing the cooling air in the drying drums, energy consumption and airflow to atmosphere are significantly reduced.

We have designed LDAN prilling plants with single-line operating capacities upto 1,250 t/day.



Ammonium nitrate prilling complex



360° lifecycle service for your plants

Putting the customer first

At thyssenkrupp Industrial Solutions we provide a holistic portfolio of high-quality service solutions focusing on the customer's added value – through the entire plant lifecycle.

With our worldwide network of local organizations and experienced representatives, as well as first-class backing from our head office, we are ideally equipped to support our customers in achieving their business goals. We place particular importance on interacting with our customers at an early stage to blend their know-how and goals with our experience. Whenever we can, we give potential customers the opportunity to visit operating plants and personally evaluate matters such as process operability, maintenance, and on-stream time. For us, cultivating sustainable business relationships and learning more about our customers' future goals are top priorities.

We provide the entire service spectrum you would expect from an EPC contractor – from parts supply and management to field and workshop services, revamps and asset management. Our service also includes regular consultancy visits to keep customers informed about the latest developments or revamping options. Working worldwide to the same quality standard certified to ISO 9001 / EN 29001, our policy is to ensure utmost quality in the implementation of all our projects. Even after project completion we make sure we stay in contact with our customers, as partnering is at the heart of our customer philosophy. By organizing and supporting technical symposia, we promote proactive communications between customers, licensors, partners, operators and our own specialists. That

way, our customers benefit from the latest technologies, an ongoing exchange of experience and relevant trouble-shooting information.

thyssenkrupp Industrial Solutions stands for tailor-made concepts and international competence. For more information contact one of the thyssenkrupp Industrial Solutions offices near you or visit our website: www.thyssenkrupp-industrial-solutions.com

Our service portfolio

- ➔ Feasibility studies / technology selection
- ➔ Project management
- ➔ Arrangement of financing schemes
- ➔ Financial guidance based on in-depth knowledge of local laws, regulations and tax procedures
- ➔ Environmental studies
- ➔ Licensing, incl. basic / detail engineering
- ➔ Utilities / off-sites / infrastructure
- ➔ Procurement / inspection / transportation services
- ➔ Civil works and erection
- ➔ Commissioning
- ➔ Training of operating personnel using an operator training simulator
- ➔ Plant operation support / plant maintenance
- ➔ Remote performance management (RPM)

Service solutions throughout the entire life cycle of your plant



Parts & supply management



Field & workshop services



Revamps & outages



Asset management

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