

Industrial Solutions

Urea

Cutting-edge fertilizer
know-how – at your
disposal



thyssenkrupp



A wealth of expertise and experience

As a customer, you profit from the wealth of know-how and experience thyssenkrupp Industrial Solutions has inherited from uhde®, a renowned partner in the engineering and construction of urea plants for six decades and now part of thyssenkrupp.

thyssenkrupp Industrial Solutions supplied and commissioned a plant for the production of 3,500 mtpd of urea solution in Sluiskil, Netherlands, for Yara of Norway, the world's biggest producer of urea.



Our plants offer you high process efficiency and reliability, low emissions and excellent product quality. Besides, we can satisfy your specific requirements by offering tailored emissions management (e.g. acidic scrubbing, absorbing technology, flaring of emissions, etc.) as well as safety analyses and assistance in permit management, including HAZOP, SIL, LOPA, QRA, safety reports, and dispersion calculations.

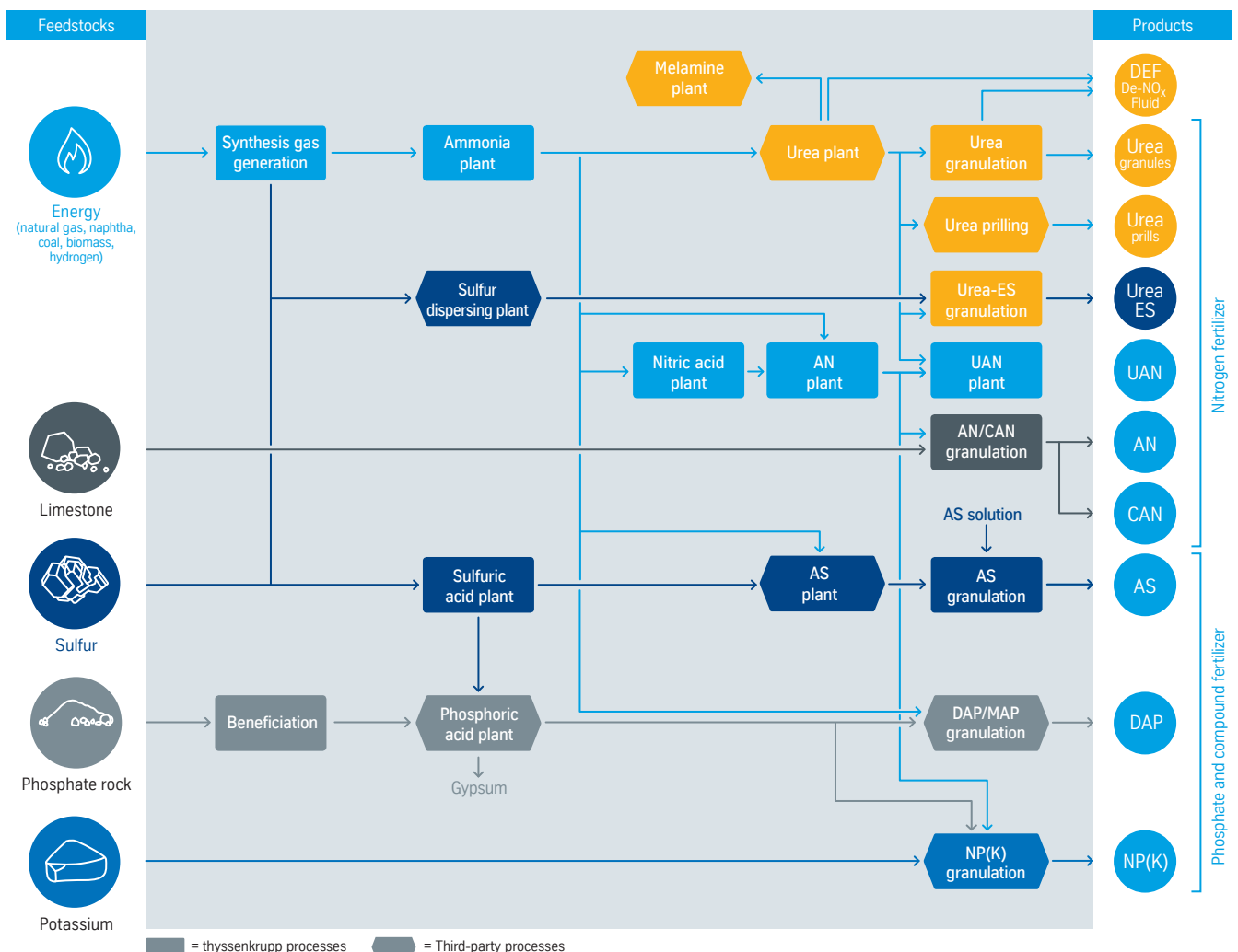
Exemplary plants are located all over the world, some in regions with extreme climatic conditions. In the last decade we have set new landmarks with 14 new fertilizer plants constructed and commissioned with a total annual urea capacity of almost 12 million tonnes. The North American market was successfully conquered as CF Industries commissioned large fertilizer complexes in Donaldsonville, Louisiana and Port Neal, Iowa, and AIR Orascom ordered a first-of-its-kind 2,200 t/day Urea Pool Reactor plant featuring an MP instead of a HP Scrubber in Wever, Iowa. The

Donaldsonville complex was commissioned in 2016, the Wever plant and the Port Neal complex in 2017. All three plants achieved emission figures significantly undercut the harsh threshold values of the local US regulations.

thyssenkrupp Industrial Solutions offers a urea production portfolio featuring top state-of-the-art technologies from leading licensors:

- ➞ Urea technology from Stamicarbon, including LAUNCH MELT™ Pool Condenser / Pool Reactor / Flash / Compact and Ultra Design, Stamicarbon's latest developments for their CO₂ stripping process
- ➞ Fluid bed granulation technologies from thyssenkrupp Fertilizer Technology and Stamicarbon
- ➞ Prilling technology from Stamicarbon

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



LAUNCH MELT™ CO₂ stripping process

How you benefit

The Urea LAUNCH MELT™ CO₂ stripping process brings you the benefits of greater reliability, longer uptimes and more efficient processes combined with simple handling and improved safety.

Lower investment and higher reliability

The high-pressure sections of recently built urea plants are made of Safurex®, a duplex steel specially developed together with process licensor Stamicarbon by the Swedish company Sandvik. This steel enables us to offer you an even greater degree of plant reliability thanks to its improved corrosion resistance in carbamate solutions and greater resistance to stress corrosion cracking. Besides, its superior mechanical properties allow wall thicknesses to be reduced without compromising on strength. Safurex® certainly pays off in investment and plant service life terms – as demonstrated by SAFCO IV, the world's first plant where the entire synthesis unit was manufactured from Safurex® – a plant engineered and constructed by thyssenkrupp Industrial Solutions.

Longer on-stream time

In today's competitive market unscheduled downtime is more costly than ever. Operational simplicity combined with gravity flow, fewer process steps, less synthesis equipment and moderate synthesis conditions facilitate operation and guarantee high on-stream times. Moreover, the operating time between planned shutdowns can be increased to four years of operation.

Improved process efficiency

The process conditions in the CO₂ stripping process result in an optimum conversion of both reactants, thus eliminating the need for an MP recirculation section and ammonia recycle. Stripping with CO₂, which is much less soluble in urea than NH₃, significantly contributes to the extremely low recycle rates. CO₂ and NH₃ consumption has been reduced to almost stoichiometric values through ongoing emission-related process improvements.

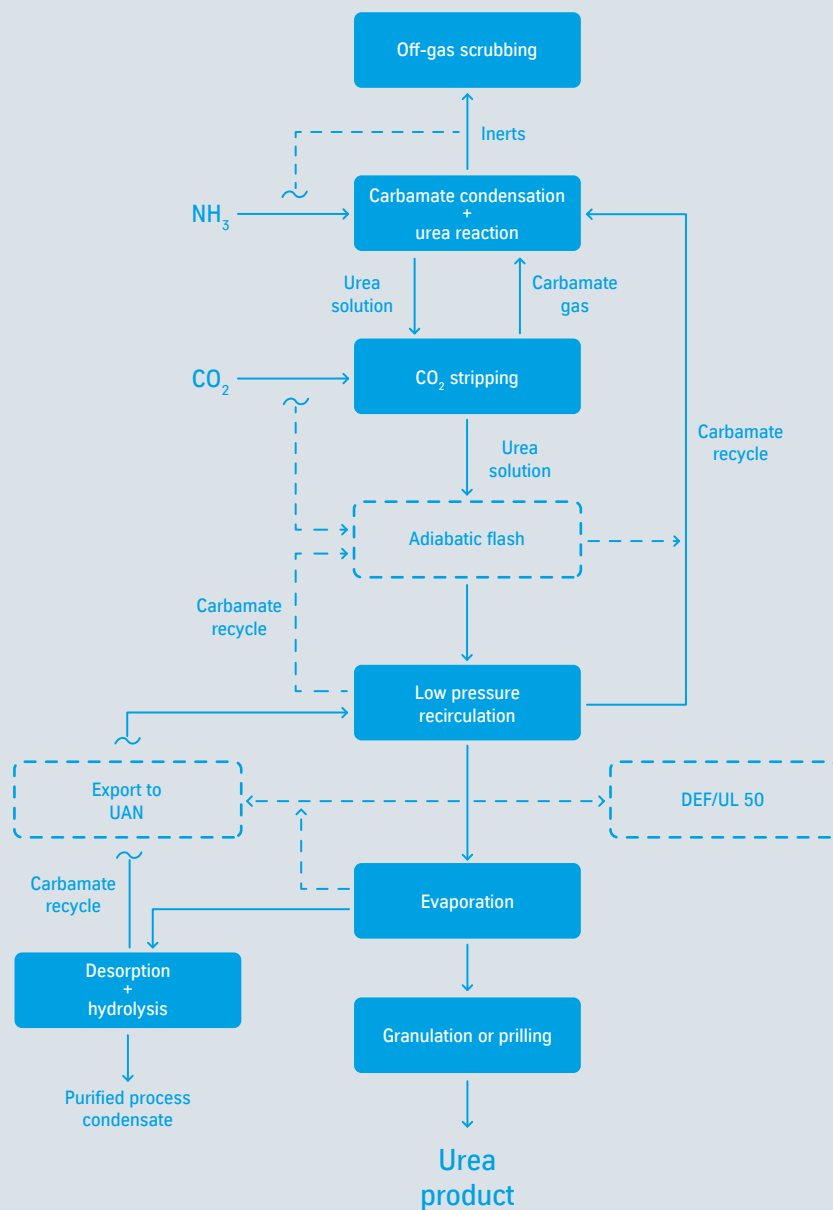
Simple operation

This CO₂ stripping process involves far less equipment and fewer process steps than competing processes. By fully exploiting recent advances in computer control technology sophisticated process control systems suit your operators' needs.

Enhanced plant safety

The Leak Detection system ensures safe operation of lined high-pressure equipment in your urea plant by instantly detecting any kind of leakage. This enables an immediate and controlled plant shutdown to prevent serious damage to your equipment and the environment. Leak Detection is an online, continuous monitoring system with a short response time in detecting possible leaks in the anti-corrosion liner of the carbon steel pressure vessel wall of HP Urea equipment.





Stay ahead of the competition
through advanced technology.

SAFCO IV fertilizer complex
in Al Jubail, Saudi Arabia.
Capacities:
3,300 mtpd of ammonia
3,250 mtpd of urea
3,600 mtpd granulation unit

The urea process synthesis

We offer our customers plants with the most reliable state-of-the-art synthesis processes:

LAUNCH MELT™ pool condenser design

LAUNCH MELT™ pool reactor design

LAUNCH MELT™ flash design

LAUNCH MELT™ compact design

LAUNCH MELT™ ultra design

**LAUNCH™ pool condenser design –
for capacities up to 6,000 mtpd**

This state-of-the-art pool condenser is basically a horizontal reactor vessel with a submerged U-tube bundle. It combines the function of the falling film-type carbamate condenser of the conventional CO₂ stripping process with part of the reactor function. A 30-40% reduction in the reactor volume is achieved by shifting this reaction volume to the pool condenser. We engineered and constructed the first urea plant with pool condenser for the QAFCO 4 fertilizer complex and since then, this technology has been realized in various urea projects. Since 2013 thyssenkrupp Industrial Solutions has successfully commissioned several plants with a capacities of about 3,500 mtpd.

**LAUNCH™ pool reactor design –
for capacities up to 2,500 mtpd**

The pool reactor makes a low plant height design with a minimal amount of piping and high-pressure equipment integrated.

We were Stamicarbon's partner in the market launch of this synthesis technology by integrating the world's first pool reactor into DSM's new urea plant at Geleen in the Netherlands, and also commissioning the world's second pool reactor in 2004. The world's biggest pool reactor with 2,200 mtpd, which we engineered, came on stream in 2016.

This design is perfectly suited for capacities from 600 mtpd up to 2,500 mtpd.

How you benefit from Stamicarbon's proven LAUNCH MELT™ pool condenser design:

- ➞ Lower investment costs thanks to the reduced size of high-pressure items
- ➞ Operational advantages, e.g. more stable level/pressure control and less sensitivity to changes in the load or the N/C ratio
- ➞ Lower construction height resulting in reduced construction costs

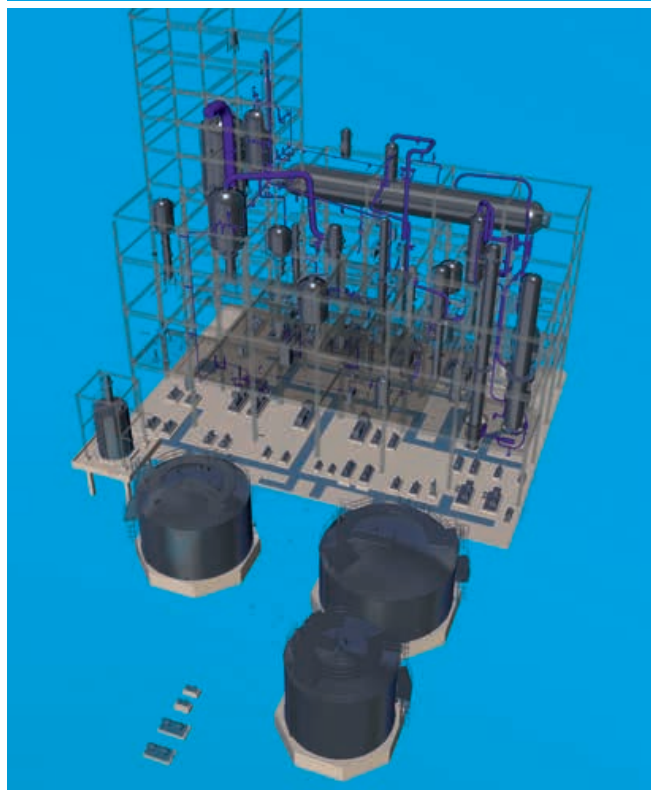


Turkmendokunhimiya's Urea synthesis plant with LAUNCH MELT™ pool reactor at Tecen, Turkmenistan, Capacity: 1,050 mtpd of urea

What drives us is the desire to deliver fit-the-future technology.



3D model of LAUNCH MELT™ pool condenser design for SAFCO IV, Al Jubail, Saudi Arabia



3D model of LAUNCH MELT™ pool reactor design for Turkmendokunhimiya, Tecen, Turkmenistan

Large single-stream plants

As a world leader in the construction of urea plants, our commitment to providing advanced fit-for-the-future technology is the driving force behind our in-house research and development. In recent years, a daily production capacity of 3,500 t of urea solution has become the norm for the single-train urea solution plants we have engineered, built and commissioned. A single stream plant with a nominal capacity of 3,900 mtpd – the biggest realized design capacity in the world – is engineered and build for BFI in Brunei. As engineering studies for even larger plants have been completed, single-train capacities of 6,000 t/day and more are now technically possible. With Stamicarbon's technology and our know-how we are in a position to build the world's largest urea plants.

Low emissions

A low NH_3/CO_2 ratio reduces the content of free ammonia in the urea solution, thereby minimizing ammonia emissions in the synthesis section. The use of state-of-the-art technology for treating gaseous and liquid effluents ensures minimal environmental impact. The outcome is a purified process condensate that can be reused as make-up water for cooling water or as boiler feedwater.

UFT Fluid Bed Granulation

Benefit from our best-in-class technology and scalable solutions

thyssenkrupp Fertilizer Technology (tkFT) is our licensor for the renowned UFT Fluid Bed Granulation technology.

Full flexibility for maximum success

The UFT Fluid Bed Granulation can produce all required product sizes (2-8 mm) in the same plant with only minimal adjustments. The urea granules are well rounded, very hard, and ultra-resistant to crushing and abrasion. Consequently the urea granules remain dust-free, non-caking and completely free-flowing, even after long storage, frequent handling and shipping. With the superior features of bulk transportability, bulk blending suitability and greater agronomical efficiency, granular urea can be substituted for prilled urea in all applications. The granulation mode is accretion, which delivers a very hard granule that is far superior in quality to granules produced through layering or agglomeration-based processes.

The UFT Fluid Bed Granulation plants are easy to operate and very reliable which result in a high on-stream factor. The granulator contains no moving parts, thus minimizing maintenance. The number of solid-handling equipment is significantly reduced compared to other technologies to maximize plant uptime and reduce investment costs.

World-class experience

The excellent product quality of UFT Fluid Bed Granulation technology has made it the global market standard for granular urea. What's more, this technology looks back on some 40 years of proven operational successes. More than 70 plants are now operating worldwide under widely varying climatic conditions. tkFT is the only licensor of urea granulation technology to have licensed 20 plants with capacities of 3,000 mt/d or more, out of which 14 are in operation.

Excellent design

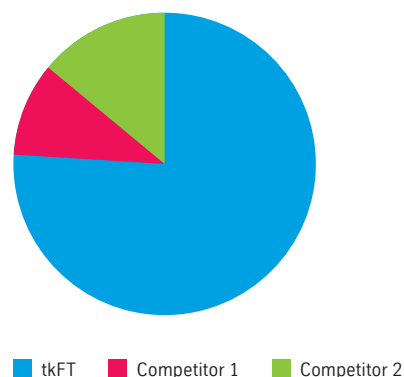
The single-stream capacities are always large enough to handle the largest urea synthesis units developed to date. With various alternative plant concepts for small or medium-sized plants available, you can also be sure of a customized design concept to meet your specific needs. The use of a 97% urea solution coupled with low recycle ratios results in a simplified design concept requiring only a single-stage evaporation unit. This leads to lower steam and cooling water consumption, minimal power consumption, and reduced investment and operating costs for the urea synthesis plant. The compact layout ensures maximum operability coupled with minimum investment costs.

One for all – for optimal operation

The tkFT process design takes climatic conditions, product quality, product size distribution, environmental regulations, product diversity, and utility costs into account to ensure you obtain a plant with the lowest costs per product ton. State-of-the-art computer based design tools backed by over 40 years of operating experience are utilized. Each plant is designed to operate optimally under its specific operating conditions.



Fluid bed granulation capacities by licensors (since 1996)



By providing leading-edge technology and services we enable our customers to deliver top-level quality products in a most cost-efficient and environmentally friendly manner.



View of a fluid bed granulator

99.9%
dust removal efficiency

>99%
ammonia removal efficiency

Zero
liquid effluents

Formaldehyde-free additive
significantly reduces environmental impact

Reducing emissions right from the start

Urea dust removed

As dust removal efficiency in excess of 99.9% can be easily achieved, dust outlet concentrations of under 0.01 kg/t of urea produced are possible. The horizontal cross-flow scrubbing system that enables such outstanding emission figures is exclusively available in combination with the UFT Fluid Bed Granulation technology.

Ammonia emissions efficiently controlled

Using acid scrubbing systems ammonia emissions meet the most stringent environmental regulations. A conventional acidic scrubbing system produces a side stream of dilute ammonium sulfate solution. tkFT proprietary Ammonia Convert Technology (ACT) avoids this side stream by recycling the ammonium sulfate solution into the final product. Traces of the micronutrient ammonium sulfate in the urea granules upgrade the resultant fertilizer with an additional economic benefit.

No contaminated water

Another key environmental benefit of the UFT Fluid Bed Granulation technology is that no liquid effluents are released into the sewage system.

Formaldehyde-free urea

Although urea formaldehyde is still the state-of-the-art urea granulation additive, it is categorized as a carcinogenic substance by the International Agency for Research on Cancer and adds to the VOC emissions from an ammonia/urea complex. That is why tkFT

developed a new formaldehyde-free additive that significantly reduces the environmental impact by virtually eliminating VOC emissions and ensures compliance with health and safety regulations on formaldehyde, while guaranteeing the same or even better granulation performance and product quality. Besides, the new formaldehyde-free additive extends the application range of urea granules with no or negligible impacts on plant.



Urea granules are produced in all requested product size distributions.

Urea-ES helps boost crop yields

The increased use of sulfur-free fertilizers, intensified cropping systems, and reduced sulfur dioxide emissions have resulted in a soil-sulfur deficit that is negatively affecting crop productivity worldwide. In 2015 experts estimated that 10 million tons of sulfur needed to be added to soil to address this sulfur deficiency and increase crop yields. Urea granules are an ideal carrier for sulfur.

By integrating the Shell Thiogro® technology into the UFT Fluid Bed Granulation process micro-particles of elemental sulfur can be included into urea to form Urea-ES. Besides agronomic advantages, our sulfurenhanced urea granules considerably improve your production efficiency.

Formaldehyde-free granules for DeNO_x and other applications

The newly developed formaldehyde-free granulation additive performs as well as or even better than urea formaldehyde. This improves the working environment as hazardous formaldehyde emissions are eliminated. The new formaldehyde-free product opens new market opportunities for you, e.g. for DeNO_x applications in power plants or as a fuel additive.

Urea-ES product specification (typical)

	Urea-ES 7	Urea-ES 13
Total nitrogen	43 wt %	40 wt %
Total sulfur	7 wt %	13 wt %
N/S ratio	6	3
Biuret	0.7-0.8 wt %	0.7-0.8 wt %
Moisture	0.2 wt %	0.2 wt %



Customer service a top priority

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

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. We always strive to build our future business on trusting relationships with our customers. 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 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

Service portfolio

- ➞ Feasibility studies / technology selection
- ➞ Project management
- ➞ Arrangement of financing schemes
- ➞ Financial guidance based on intimate 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

Industrial Solutions
Fertilizer and Syngas Technologies

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