Industrial Solutions

Ammonia technology

Boost your business with our leading fertilizer technology

thyssenkrupp

Cutting-edge technology since 1928

The first ammonia plant to use an uhde® proprietary process went on stream at a German coalmine site way back in 1928.

Ammonia plant in fertilizer complex in Tecen, Turkmenistan
Capacities: 600 mtpd of ammonia
1,050 mtpd of urea synthesis
1,050 mtpd granulation unit

Around 90 years of turnkey EPC solutions – tailored to our customers' needs.

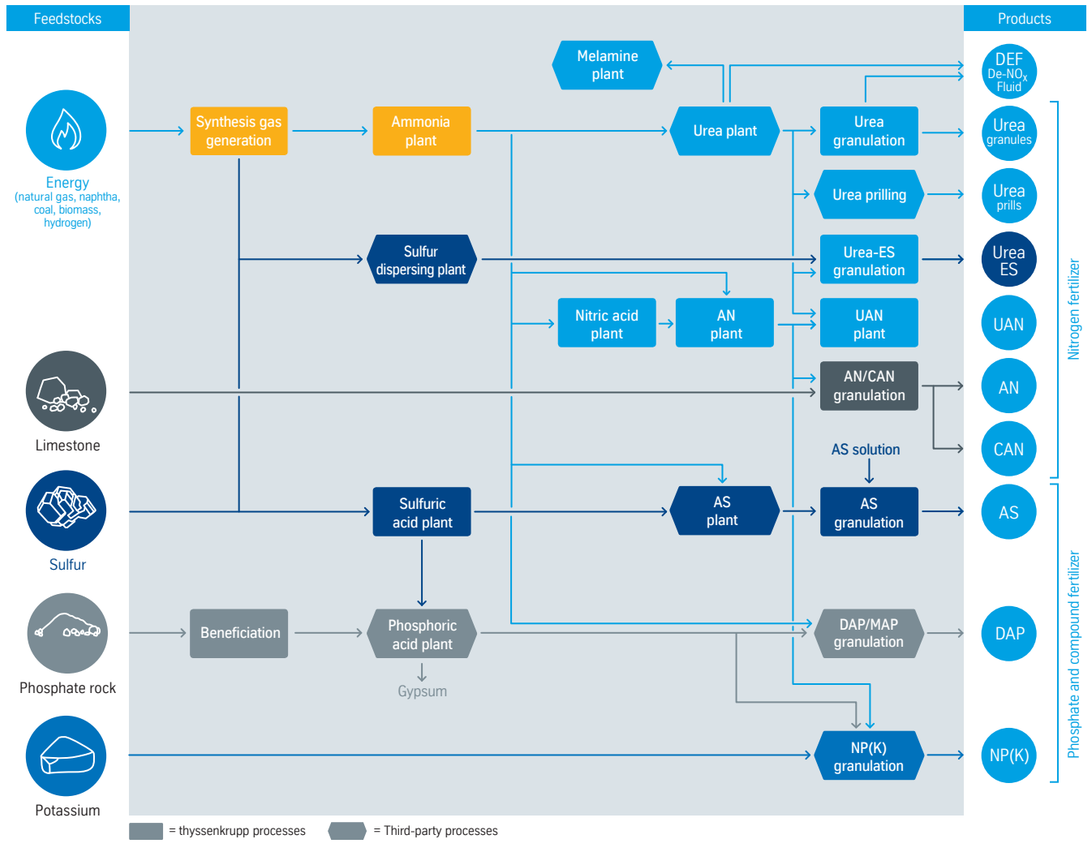
The first plant built in 1928 had an ammonia output of 100 metric tons per day (mtpd). These first uhde®-engineered ammonia reactors featured a remarkably efficient technology with an internal heat exchanger and a synthesis loop with an integrated two-stage refrigeration unit. uhde® never lost its focus on energy efficiency, as evidenced by the design of a plant with an energy consumption of only 7.8 Gcal/mt of ammonia as early as 1968. Nowadays we are ready to design down to 6.4 Gcal/mt of ammonia.

To improve plant efficiency even further, the focus has been on reducing power consumption, improving process heat recovery, minimizing stack losses, and cutting energy consumption for CO_2 removal. With around nine decades of experience and broadly based expertise we are continuing to make improvements in energy efficiency, plant operability and reliability possible. More recent milestones in ammonia technology were achieved at plants we built in Al Jubail, Saudi Arabia, and Louisiana, USA, both featuring a single-train capacity in excess of 3,300 mtpd.

This brochure tells you more about the state-of-the-art ammonia plant technology we offer to customers worldwide and, in particular, what benefits it will bring to you.

100 mtpd: In 1928 the first ammonia plant started production for the Mont-Cenis Mine in Herne, Germany.

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

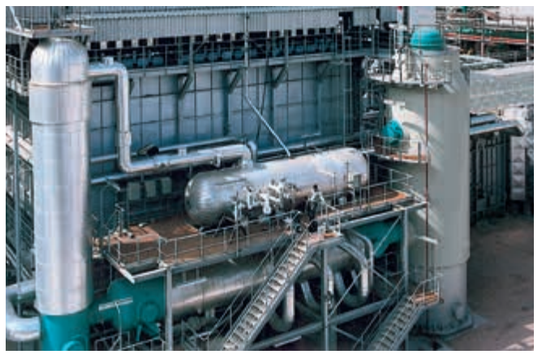


Pioneers in critical plant equipment

A good process on its own is not enough. Reliable designs for critical items of equipment are just as important. Only a combination of the two will make a good plant. At thyssenkrupp Industrial Solutions we have pioneered the development of essential items of equipment for ammonia plants:

- Primary reformer with a cold outlet manifold system
- Secondary reformer
- Process gas cooling train downstream of the secondary reformer for generating and superheating high-pressure steam
- High-efficiency ammonia converter system with up to three beds, indirect heat exchange and radial flow
- Ammonia synthesis waste heat boiler

Such innovative developments have made us one of the leading technology providers in this field. We hold a number of patents for such equipment and have granted numerous manufacturing and marketing licenses to equipment manufacturers and chemical engineering contractors.



Secondary reformer and process gas cooling train

uhde® primary reformer

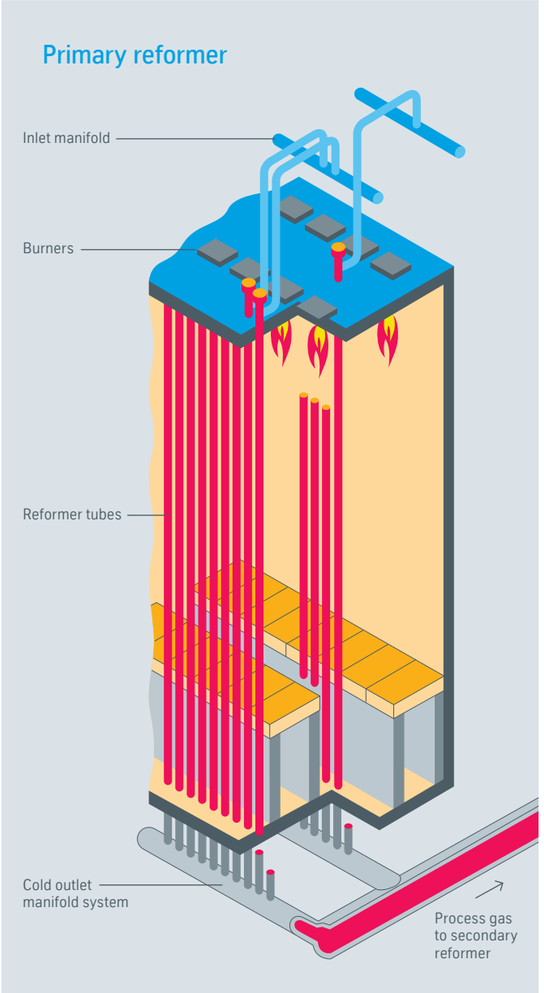
The uhde® primary reformer is a furnace in which tubes filled with catalyst are heated by burners located in the furnace ceiling. The process gas temperature required at the outlet of the catalyst-filled tubes is about 800°C at a pressure of approx. 45 bar. Inevitably, the service life of components such as the reformer tubes is limited. Reformer tubes regularly exceed their expected lifetime. The gas leaving the tubes is routed through a refractory-lined cold outlet manifold system to a secondary reformer.

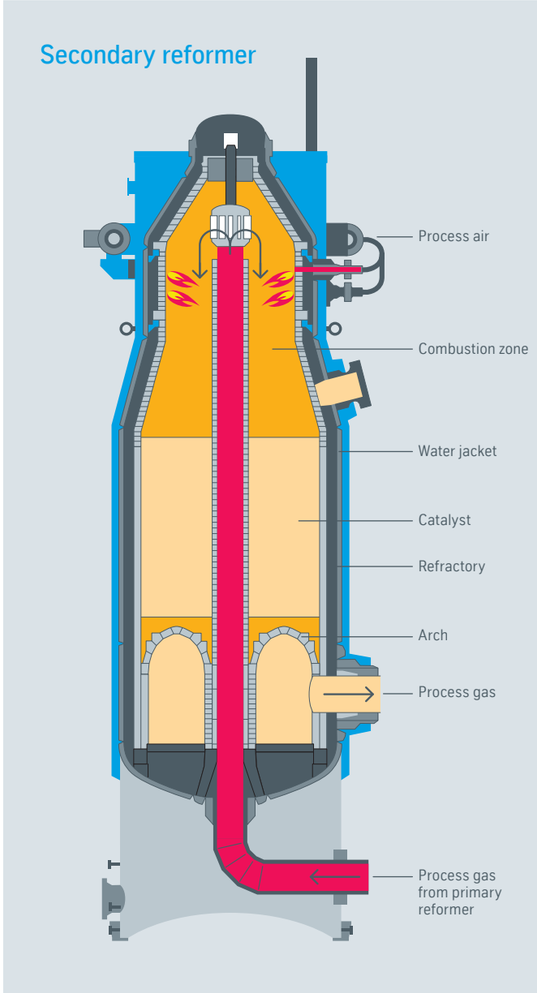
uhde® secondary reformer

The process gas leaving the primary reformer enters the secondary reformer at the bottom. The gas is routed through the central internal riser pipe into the combustion chamber at the top of the secondary reformer. Process air is introduced into this combustion chamber via nozzles, arranged around the circumference of the combustion chamber. The partially oxidized gas passes from top to bottom through the catalyst bed, which is supported by a ceramic arch. Finally, the gas leaves the secondary reformer at the bottom.

Cooling train equipment

The process gas from the secondary reformer has to be cooled from 1,000°C to a controlled temperature suitable for the downstream CO shift. The sensible heat can best be utilized in the generation and superheating of high-pressure steam. The challenge in designing suitable cooling train equipment is to arrive at a concept that provides safe temperature limitation for all parts according to their particular load sensitivity and materials of construction. In addition, the equipment has to be available at competitive prices. For five decades we have both used and promoted the use of the horizontal fire-tube boiler and a high-pressure steam superheater.





Innovative developments have made us one of the leading technology providers in this field.

uhde® ammonia converter and waste heat recovery

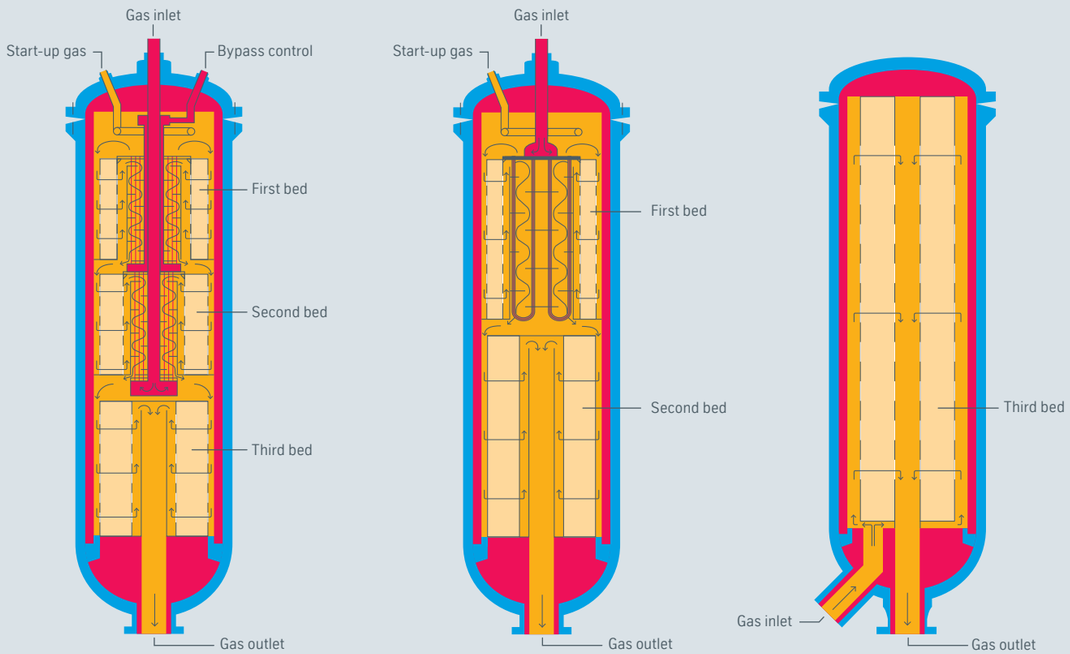
The demand for energy-efficient ammonia production dictates the design of the ammonia synthesis unit so that it can deliver the following beneficial features:

- High conversion rates and large catalyst volume
- Maximum utilization of reaction heat for generation of high-pressure steam
- Low pressure drop in the loop

To fulfill these demands, the uhde® ammonia synthesis design incorporates three radial-type catalyst beds arranged in either one or two ammonia converters.
At thyssenkrupp Industrial Solutions we look back on a long tradition of designing high-pressure synthesis loop boilers, having pioneered this type of equipment in 1969.

Ammonia plant in Ma'aden, Saudi Arabia
Capacity:
3,300 mtpd of ammonia

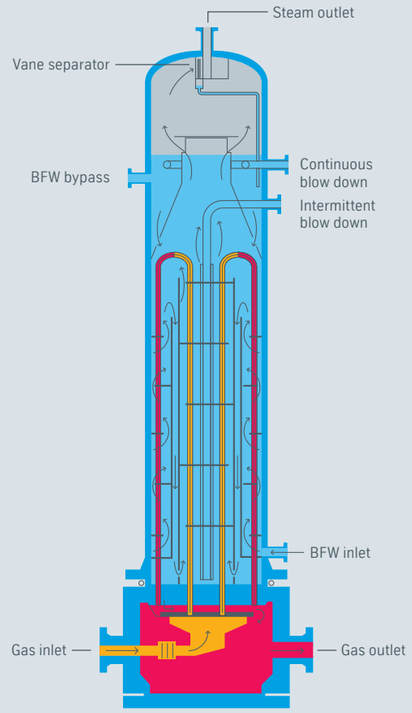
The uhde® ammonia synthesis design incorporates three radial-type catalyst beds arranged in either one or two ammonia converters.



Three-bed ammonia converter

Ammonia converter I, catalyst beds 1 and 2

Ammonia converter II, catalyst bed 3



HP steam boiler with integrated BFW preheater

Improved energy efficiency and higher capacities

Mega plants – A30 Series

With our uhde® dual-pressure process we are the only technology provider in the market with proven design capacities above 3,000 mtpd.

For many years, the capacities of chemical plants have been growing significantly to lower specific production costs through economies of scale. More than ever before, the plant construction sector is now being challenged to exploit this advantage while continuing to employ proven technologies and equipment. Together with catalysts supplier Johnson Matthey we have risen to this challenge and developed a process that, based on existing technology and tried-and-tested equipment, makes ammonia plants with a capacity of 4,000 - 5,000 mtpd possible.

uhde® dual-pressure process
The key innovation of the uhde® dual-pressure process is an additional medium-pressure, once-through ammonia synthesis connected in series with the conventional high-pressure ammonia synthesis loop. The first plant to apply this process was the SAFCO IV ammonia plant in Al-Jubail, Saudi Arabia, with a capacity of 3,300 mtpd, which started up in 2004. Since then, three more plants based on the uhde® dual-pressure process have come on stream with similar capacities. Ma'aden 1 & 2 in Saudi Arabia and CFI Donaldsonville in USA are all exceeding their design capacities.

In the uhde® dual-pressure process make-up gas is compressed in a two-stage intercooled compressor, the low-pressure (LP) casing of the syngas compressor. The pressure at the discharge of the compressor is approx. 110 bar, a pressure at which the three-bed, intercooled, once-through converter produces approx. one third of the total ammonia output. The syngas-ammonia mixture leaving this converter is cooled and most of the ammonia produced is separated from the gas as liquid.

The remaining syngas is then compressed in the high-pressure (HP) casing of the syngas compressor to the operating pressure of the ammonia synthesis loop (up to 210 bar). Since the syngas has been cooled down, the HP casing can operate at a much lower temperature than in the conventional ammonia process. The remaining two thirds of the total ammonia output are produced in this conventional ammonia synthesis loop.

How you benefit from this technology

- Synthesis capacity of approx. 3,300 mtpd of ammonia now possible using provably reliable and efficient conventional equipment from 2,000 mtpd ammonia plant
- Use of well-proven magnetite-based catalysts in all stages of the new process
- Improvement in energy efficiency compared to conventional ammonia process
- Reduced piping sizes in the high-pressure loop thanks to a high conversion rate in the high-pressure synthesis loop combined with reduced production requirement
- Syngas compressor of 3,300 mtpd dual-pressure plant not bigger than that of current 2,000 mtpd ammonia plants
- No major deviations from proven process conditions

Fertilizer complex no. 4 (SAFCO IV) for Saudi Arabian Fertilizer Company in Al-Jubail, Saudi Arabia
Capacities: 3,300 mtpd of ammonia
3,250 mtpd of urea
3,600 mtpd granulation unit

4,000 - 5,000 mtpd
Process also suitable for even larger plants

Plants of persuasive efficiency and reassuring reliability

World-scale plants – A20 Series

Our world-class ammonia process is reliably operated by our customers under all climatic conditions. Moreover, we have globally proven our sustainable competence by building the A20 Series, including downstream process plants and off-sites & utilities on a fully wrapped lump-sum EPC basis. All this underlines our claim to be the top provider of EPC solutions in the ammonia business.

With our A20 Series we have successfully established an efficient and highly reliable ammonia plant. Plants of the A20 Series are operated by customers such as BASF in Belgium, CFI in USA, Fertil in UAE, QAFCO in Qatar and Sorfert in Algeria. Since 2013, we have put into operation four of these plants on three continents with capacities of 2,000-2,200 mtpd.

The A20 Series essentially shares the same basis as the A30 Series (except for the once-through ammonia synthesis section) and comprises the following process steps:

- Steam methane reformer for synthesis gas generation
- Secondary reforming and CO conversion
- HP steam generation and superheating
- CO_2 removal based on amine solvents with subsequent methanation
- Multi-stage synthesis gas compression
- Ammonia loop synthesis with three catalyst beds located in two ammonia converters with radial flow, internal heat exchanger and two waste-heat boilers for HP steam generation
- Ammonia-based refrigeration system

Four world-scale plants on three continents with capacities of 2,000 - 2,200 mtpd – since 2013

Sorfert fertilizer complex in Arzew, Algeria
Capacities: 2 x 2,200 mtpd of ammonia | 1 x 3,450 mtpd of urea

Exceptional experience in cost-efficient plant design

Mid-sized plants – A10 Series

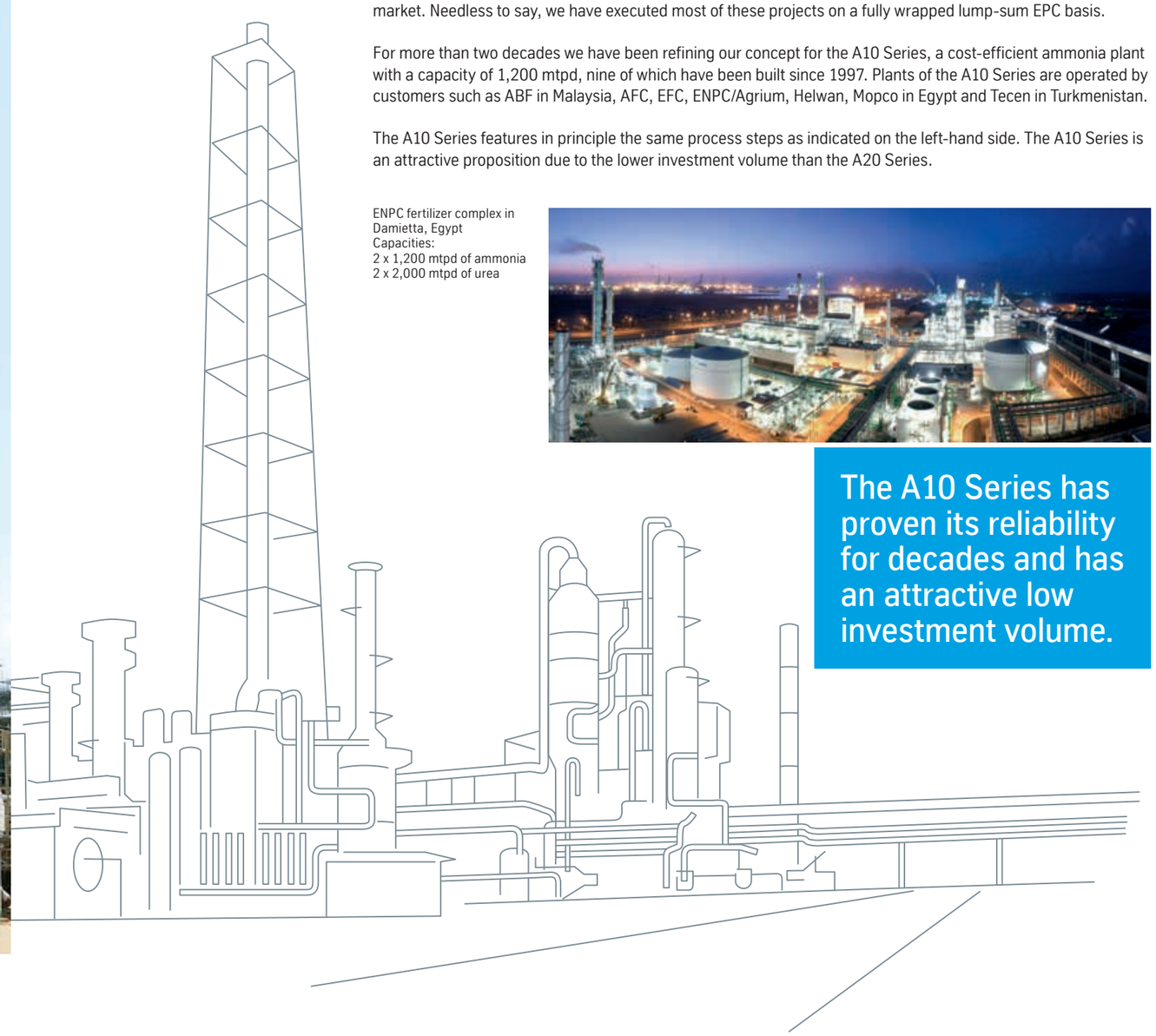
Thanks to its cost-efficient plant design the A10 Series is one of the most requested plants in the ammonia market. Needless to say, we have executed most of these projects on a fully wrapped lump-sum EPC basis.

For more than two decades we have been refining our concept for the A10 Series, a cost-efficient ammonia plant with a capacity of 1,200 mtpd, nine of which have been built since 1997. Plants of the A10 Series are operated by customers such as ABF in Malaysia, AFC, EFC, ENPC/Agrium, Helwan, Mopco in Egypt and Tecen in Turkmenistan.

The A10 Series features in principle the same process steps as indicated on the left-hand side. The A10 Series is an attractive proposition due to the lower investment volume than the A20 Series.

ENPC fertilizer complex in Damietta, Egypt
Capacities:
2 x 1,200 mtpd of ammonia
2 x 2,000 mtpd of urea

The A10 Series has proven its reliability for decades and has an attractive low investment volume.



The benefits of downsizing

Small-scale plants – A04 Series

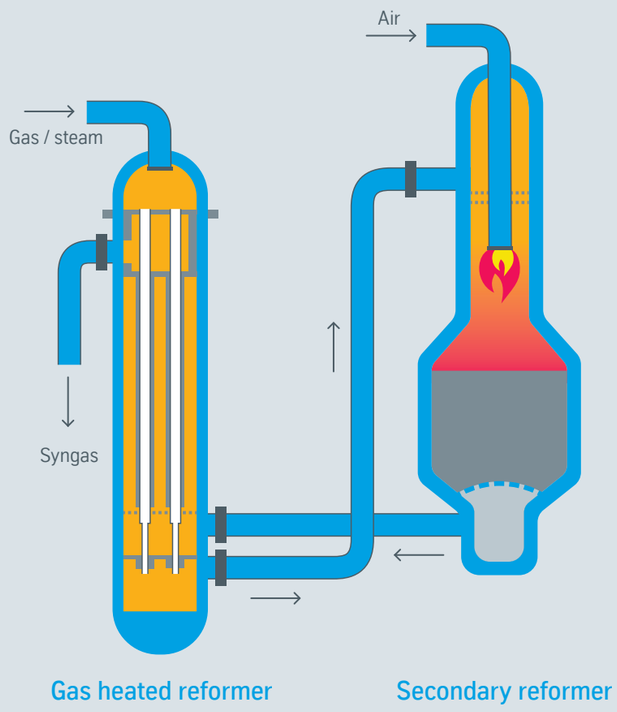
The A04 Series is a perfect match for producers in locations with low ammonia needs and high transportation issues.

The chemical and fertilizer industries have relied upon large-scale ammonia plants during the past four decades because economies of scale have favored lower specific construction and production costs. The business model for these larger plants was partly based on the fact that ammonia not consumed on site could be exported via relatively easy transportation to other users at economically attractive prices. However, increasing safety and security concerns regarding the transportation of hazardous chemicals have led to higher freight rates and insurance premiums for anhydrous ammonia. This affects most small-scale ammonia consumers who depend on importing ammonia by railcar, barge or road.

New ammonia plant concept for 250 - 550 mtpd
A viable alternative is to co-locate a small-scale ammonia production facility with a consuming facility and thus eliminate the transport risk and costs. As conventional plant designs face technical and economic challenges at plant capacities below 550 mtpd, we collaborated with Johnson Matthey to develop an economical concept for smaller plants based on gas heated reformer (GHR) technology with a pressure swing adsorption (PSA) system at the front end and an uhde® low-pressure synthesis loop at the back end. As a result, we can now offer plants with capacities of 250 - 550 mtpd.

Gas heated reformer design

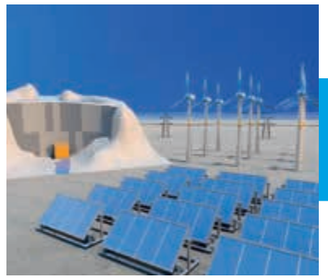
Johnson Matthey's GHR is basically a shell and tube heat exchanger with a catalyst inside the tubes. The partially reformed gas leaving the GHR tubes flows to the secondary reformer where process air is added and further reforming takes place. Hot gases leaving the secondary reformer provide the heat for the GHR's reforming reaction. The design is best suitable for small ammonia capacities. Several references already exist.



Your new ammonia source

Micro plants – A01 Series

A CO_2-free ammonia plant installed at a renewable energy source and featuring our proven technologies: the A01 Series combines thyssenkrupp water electrolyis with uhde® ammonia synthesis.


Electricity from renewables

thyssenkrupp water electrolysis

uhde® ammonia synthesis by thyssenkrupp

Ammonia applications

By using green energy from solar power, wind power, hydropower or other renewable sources, ammonia can be produced in a sustainable way – quite literally from air and water. Our large-scale water electrolysis solution offers you significant economic advantages.

The patented large cells make highly efficient, industrial-scale hydrogen production possible. With our world-class ammonia process and globally proven EPC competence we can offer a complete plant for producing ammonia from atmospheric nitrogen and electrolytic hydrogen – with no CO_2 emissions. Thanks to proven processes from hundreds of chemical plants you profit from the high overall efficiency and reassuring reliability for optimal yields.

Sun, air, water – your new ammonia source

Ammonia applications:

- Fertilizer applications
- $DeNO_x$, e.g. for power plants
- Melamine
- Amination / nitrification chemistry, e.g. for polyurethanes, polycarbonates
- Green energy storage

How you benefit from the electrolysis-based ammonia process:

- Proven designs based on operating reference plants
- Low-pressure synthesis with centrifugal compressor using uhde® radial flow-type ammonia reactor
- Cobalt-promoted magnetite catalyst with proven long-term reference for low-pressure synthesis
- Reduced complexity and O&M expenses
- 50 mtpd capacity modules reduce field construction time and associated costs

Flexible feedstocks – raw materials

In the ammonia process the ammonia molecule is synthesized from a mixture of hydrogen and nitrogen. In most conventional ammonia plants, hydrogen is produced by steam reforming of natural gas.

Other suitable hydrogen sources for ammonia production are:

- Steam reforming of naphtha
- Hydrogen from water electrolysis
- Steam reforming of biogas
- Coal gasification
- Biomass gasification
- High-purity industrial hydrogen
- Hydrogen-rich offgas from methanol plants or other processes

Nitrogen is typically supplied from compressed air or as high-purity nitrogen from an air separation unit (ASU). At thyssenkrupp Industrial Solutions we can adapt our ammonia technology to process all of the above feedstocks. Depending on their origin the feedstocks contain components that can be harmful to catalysts or lower the overall efficiency of the plant. We can provide you with the necessary process steps to eliminate the unwanted substances, for example:

- Helium removal
- Mercury removal
- Chlorine removal
- Hydrogenation
- Pre-desulfurization
- Deep desulfurization

The specific technical solution will be tailored to your process requirement and needs.

360° life cycle service for your plants

Putting the customer first

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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