Nitric acid plants
Efficient, economic and environmentally friendly

thyssenkrupp
Know-how that breeds success

With over a century of involvement in nitric acid plant design and construction, more than 80 years of experience in the fertilizer sector and more than 360 plants engineered and delivered, thyssenkrupp Industrial Solutions is best placed to serve the industry with proven, economic and environmentally friendly processes.

We can deliver the full range of plants for the production of single-component and mixed nitrogenous fertilizers, based on both our own proprietary and renowned licensed technologies. For the non-fertilizer industry we can supply plants for azeotropic nitric acid. Our EnviNOx® tail gas treatment technology, the gold standard of performance for N₂O and NOx emission reduction, makes our nitric acid plants environmentally friendly. The diagram below provides an overview of the principal fertilizer routes as well as the available processes and main licensors. This brochure describes the processes we offer for nitric acid manufacture. Our nitrates, urea, ammonia and EnviNOx® tail gas treatment processes are covered in separate publications.

The complete process chain for the production of different fertilizers:

<table>
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<th>Products</th>
<th>Processes</th>
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<tr>
<td>Urea</td>
<td>Synthesis Gas Generation</td>
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<tr>
<td>UAN</td>
<td>Ammonia Plant</td>
</tr>
<tr>
<td>AN</td>
<td>Urea Plant</td>
</tr>
<tr>
<td>CAN</td>
<td>Urea Granulation</td>
</tr>
<tr>
<td>AS</td>
<td>UAN Plant</td>
</tr>
<tr>
<td>CAN/CAN</td>
<td>Non-fertilizer uses</td>
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<tr>
<td>DAP</td>
<td>AS Solution</td>
</tr>
<tr>
<td>MAP</td>
<td>AS Granulation</td>
</tr>
<tr>
<td>NP(K)</td>
<td>DAP/ MAP Granulation</td>
</tr>
<tr>
<td>NPK</td>
<td>Gypsum</td>
</tr>
<tr>
<td>Potassium</td>
<td>Beneficiation</td>
</tr>
<tr>
<td>Phosphate Rock</td>
<td>Phosphoric Acid Plant</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Sulfuric Acid Plant</td>
</tr>
<tr>
<td>Limestone</td>
<td>Energy (natural gas, naphtha, coal, biomass, hydrogen)</td>
</tr>
</tbody>
</table>

The absorption tower is one of the key elements of the nitric acid plant and, with its many cooling coils connections, one of the most unmistakable.
thyssenkrupp Industrial Solutions, a market leader in nitric acid technology, have the longest experience in nitric acid as well as the largest reference list. Whether your daily nitric acid requirement is for 20 or 2000 tons, thyssenkrupp can meet your needs with a highly efficient, eco-nomic, environmentally friendly plant which is tailored to your special situation. Nitric acid product concentrations are between around 60 wt.% typically for ammonium nitrate production, and 68 wt.%, the feedstock for organic syntheses which ultimately lead to such materials as soft and hard polyurethanes.

A plant can also be configured to produce both concentrations. thyssenkrupp’s award-winning and BAT rated EnviNOx® system solves all current emission problems and future-proofs your plant against coming more stringent regulations. With its unrivalled N₂O and NOₓ abatement performance EnviNOx® can also open opportunities for income generation in emissions trading systems, CO₂ tax regimes and the like.

Friedrich Uhde, who founded the company that went on to become part of thyssenkrupp, cooperated with Wilhelm Ostwald to build the world’s very first nitric acid plant using ammonia oxida-tion. Friedrich Uhde’s pioneering work is honored in the name of our modern nitric acid processes: uhde®.

The process gas is cooled below the condensation temperature and the first nitric acid forms. This is typically an area of high corrosion. thyssenkrupp’s sophisticated acid condensation equipment avoids the conditions which promote corrosion, leading to longer life for cooler condensers and other heat exchangers.

Nitrogen oxides (NO and NOₓ) are absorbed in water in a cooled absorption tower of proprietary thyssenkrupp design. The nitrogen oxides remaining in the tail gas are at a low concentration enhancing overall plant efficiency.

After absorption the remaining nitrogen oxides (NOₓ and N₂O) are reduced to very low levels to meet the most stringent emis-sion regulations. Even at plant start-up, typically a time of high emissions, an EnviNOx® system can significantly cut unsightly brown stack plumes.

Efficient, economic and environmentally friendly: thyssenkrupp Nitric Acid Plants

Ammonia, Air

Ammonia oxidation

Heat recovery

Acid condensation

Absorption

EnviNOx® tail gas treatment

Nitric acid product

Clean tail gas

Heat recovery

The heat of reaction is recovered by producing steam and heating tail gas. The hot tail gas and part of the steam are used in the turbines that drive the plant compressors, while the rest of the steam is exported.

Ammonia oxidation

Ammonia is mixed with atmospheric air and converted to nitrogen oxides over a platinum/rhodium catalyst. thyssenkrupp’s proprietary ammonia burner design ensures an even distribution of reactants resulting in very high conversion efficiencies.

Acid condensation

The acid produced in the absorption tower contains dissolved nitrogen oxides. These are removed from the acid in the bleaching tower, by stripping with secondary air.

Absorption

The acid produced in the absorption tower is cooled below the condensation temperature and the first nitric acid forms. This is typically an area of high corrosion. thyssenkrupp’s sophisticated acid condensation equipment avoids the conditions which promote corrosion, leading to longer life for cooler condensers and other heat exchangers.

Nitric Acid Bleaching

The acid produced in the absorption tower contains dissolved nitrogen oxides. These are removed from the acid in the bleaching tower, by stripping with secondary air.
uhde® dual pressure nitric acid process

In a dual pressure plant each part of the process operates at its optimum condition:

- Ammonia oxidation 4 – 6 bar
- Absorption 10 – 14 bar

This maximises the overall plant efficiency in terms of low specific ammonia consumption and allows the plant to operate for long periods before the precious metal ammonia oxidation catalyst gauzes need to be changed.

Thanks to the EnviNOx® N₂O and NOx abatement system the plant discharges very clean tail gas.

How you benefit:

The uhde® dual pressure nitric acid process has a range of special features which contribute to plant reliability, efficiency and flexibility, such as:

- High efficiency ammonia burner
- Optimised heat recovery
- Corrosion-avoiding acid condensation system
- Patented seal gas system for nitrous gas compressor
- Range of nitric acid concentrations from typically 60 wt.% to 68 wt.%

uhde® dual pressure plant capacities start from around 500 t/day. The largest completely single train plants go up to 1600 t/day and higher capacities well over 2000 t/day are possible.

High efficiency for world-scale plants
uhde® mono pressure nitric acid process

The ammonia oxidation and the absorption operate at the same pressure of 7 – 12 bar.

The result:
smaller equipment and pipe size and reduced equipment count leading to lower investment costs.

How you benefit:
All the special thyssenkrupp features are present in this design:

- low investment
- high efficiency ammonia burner
- optimised heat recovery
- corrosion-avoiding acid condensation system
- high performance NOx and N2O abatement with EnviNOx®
- choice of product acid concentrations up to 67 wt.%, or two concentrations at the same time, such as 60 wt.% and 68 wt.%

The uhde® mono pressure nitric acid process comes into its own at capacities below about 500 t/day.

The ideal choice for low capacities
uhde® azeotropic nitric acid process

While 60% nitric acid is usually required for fertilizer manufacture, the non-fertilizer industry demands higher concentrations. Nitric acid with a concentration of up to 68% can be produced with the uhde® azeotropic process. Among the special features which make this possible are:

- Drying of process air by nitric acid side stream to prevent dilution of product acid by atmospheric moisture
- Absorption tower performance improved by cooling with cold water chilled by plant ammonia feed evaporation
- Precise design to obtain high NO\(_2\) partial pressure at process gas inlet of absorption tower

How you benefit:

The uhde® azeotropic nitric acid process incorporates all the special features which contribute to plant reliability, efficiency and flexibility, such as:

- High efficiency ammonia burner
- Optimised heat recovery
- Corrosion-avoiding acid condensation system
- Patented seal gas system for nitrous gas compressor
- Very low emissions due to high performance NOx and N\(_2\)O abatement with EnviNOx®
- Product acid concentrations up to 68 wt.%
- Two different product acid concentrations at the same time, such as 68 wt.% and 60 wt.%

68 wt.% nitric acid for the chemical industry

EnviNOx® - the gold standard for N\(_2\)O and NOx abatement

The potent greenhouse gas nitrous oxide (N\(_2\)O) is formed in the ammonia burner as an unwanted side-product. The nitrous oxide passes through the rest of the nitric acid plant unchanged and is discharged to atmosphere with the tail gas. The tail gas also contains small amounts of other nitrogen oxides, NO and NO\(_2\) (NOx) which are damaging for the environment and human health.

With an EnviNOx® system installed in the tail gas line upstream of the tail gas expander, NOx and N\(_2\)O emissions can be reduced to very low levels indeed. The technology is applicable over a wide range of tail gas temperatures.

Ammonia is used as a reducing agent for NOx, and N\(_2\)O is either catalytically decomposed, or reduced with a small amount of a hydrocarbon such as natural gas. NOx outlet concentrations of less than 1 ppm and 99% N\(_2\)O abatement rates can be achieved, making a nitric acid plant with EnviNOx® a very clean plant.

The NOx removal component of the EnviNOx® system can be installed separately if N\(_2\)O emissions are not yet an issue. An interesting option where additional flexibility is required is the EnviNOx® Ready system. The EnviNOx® reactor initially reduces NO\(_x\) but can be simply upgraded to also destroy N\(_2\)O at a later stage.

During start-up many nitric acid plants emit a brown stack plume, due to the high NOx concentration in the tail gas. A plant equipped with an EnviNOx® system can be tuned with the aid of tkIS® engineers to reduce NOx emissions before the light-off of the ammonia burner. The result is an invisible stack plume, even during this critical phase.

With more than 50 systems and a total cumulative greenhouse gas reduction of over 120 million t CO\(_2\)e, EnviNOx® technology continues to make a significant contribution to protecting the environment.

How you benefit:

- Unrivalled high abatement rates of N\(_2\)O and NOx
- EnviNOx® system is in tail gas stream, thus no interference with nitric acid process
- Non-toxic catalyst materials simplify handling
- Works over a wide range of temperatures
- Can reduce NOx emissions even during start-up
- Abate NOx now and N\(_2\)O later when required, with an EnviNOx® Ready system
- Equally suited to new plants or as a retrofit to existing plants

For further details please refer to our separate EnviNOx® brochure.