Urea and Nitric Acid Plants: Improvement of Shut-Down, Revamping, Debottlenecking and Refurbishment

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A presentation on special corrosion-resistant steels for nitric acid and urea service and the role played by strategic equipment from experienced suppliers and technical support in saving time, stress and money.

INTRODUCTION: UREA AND NITRIC PLANTS: DIFFERENT SOLUTIONS FOR DIFFERENT CORROSION PHENOMENA

Urea and nitric acid plants are prone to various corrosion phenomena, depending on factors such as the process, the concentration, the temperature and the composition of the gas itself.

It is also important to stress that the role of impurities and process variables such as the oxygen content in urea carbamate solutions and oxidizing impurities in nitric media is generally as important as the nominal composition. In all cases the chlorides or halogen contents are also important.

Therefore special austenitic stainless steels with specific characteristics have been developed. Past experience has shown that, although applying inferior materials was an attractive solution because they are standard, easier to find and cheaper, they are not reliable and lead sometimes to safety risks and/or unplanned shut-downs.

Even if most of the problems can be anticipated by regular shut-downs (maintenance), some issues can occur unexpectedly. In such situations the plant is out of operation for an indefinite time during which it is not only not producing, but also sometimes impacting downstream production.

SPECIAL STAINLESS STEELS FOR UREA AND NITRIC APPLICATIONS

Urea

The urea manufacturing process requires special stainless steels able to withstand severe production conditions. The cocktail of corrosive carbamate, high pressure (140-200 bar) and high temperature (up to 200°C) requires special stainless steel grades such as 316L UG and/or 25.22.2 (WNR.1.4465/1.4466 – UNS S31050).
To guarantee the lifetime of their installations, specialized licensors such as Stamicarbon/Tecnimont, Saipem (formerly Snamprogetti), Toyo and Urea Casale have developed their own specifications for the chemical composition, micrographic structure, mechanical properties and corrosion resistance (Huey Tests) of stainless steels.

**316L UG (Urea Grade) – WNR.1.4404/1.4406/1.4429/1.4435**

Also called 316L modified, the austenitic stainless steel 316L UG corresponds to different Werkstoff Nummer, depending on the content of nickel, molybdenum or nitrogen. This grade has extra low carbon and silicon contents, a higher molybdenum content, and sometimes high nitrogen additions. Also, the ferrite level of this particular grade is set to maximum 0.6%. These modifications aim at improving corrosion resistance in urea carbamate solutions.

**25.22.2 – UNS S 31050 – AISI 310 Mo LN – WNR. 1.4465/1.4466**

The 310MoLN grade has an optimized chemical composition for specific applications in urea plants. Carbon content is low and chromium and nickel have respective levels of 25% and 22%. Moreover, silicon content is also low and nitrogen is added to this chemical composition, which stabilizes and strengthens the austenitic phase.

As for 316L UG, the maximum acceptable ferrite level is 0.6%. The grade 310MoLN is a fully austenitic stainless steel free of intermetallic phases as intergranular carbide precipitations, which drastically affect its corrosion-resistance in urea solutions. This alloy is designed to improve corrosion-resistance in urea-carbamate environments, for example, in high-pressure strippers.

**Nitric acid**

Depending on its concentration and temperature, nitric acid (HNO₃) may require special stainless steel grades with low molybdenum contents.

For concentrated nitric acid solutions, the addition of 4% silicon to austenitic stainless steels like 304L favourably influences their resistance to intergranular corrosion. This gave birth to the grade WNr.1.4361 – UNS S 30600- Uranus S 1® (chemical composition: 18% Cr, 15% Ni, 4% Si). This effect is clearly visible in Fig. 1, where URS1 exhibits unique behaviour in comparison with all other stainless steels.

![Corrosion rates in HNO₃](image)

**Fig. 1:** Corrosion rates in HNO₃
In boiling nitric acid solutions, the best results are obtained with high-chromium grades. With a chromium content of 25%, URANUS 65®, a 310L NAG (Nitric Acid modified Grade), outperforms 304L in boiling 65% acid. Its low carbon and phosphorus and its silicon content (< 0.3%) also improve its corrosion-resistance and phase stability (Figs. 1 and 2). To maintain the austenitic structure, nickel has been also increased to around 20%. This grade is also known as WNR.1.4335 - URANUS 65 ®.

Figures 1, 2 and 3 (from Arcelor Mittal) show the corrosion rates measured on different kinds of stainless steels, according to the concentration of nitric acid, as well as the results of the Huey Tests on these different grades.

**Fig. 2:** Corrosion rate in boiling HNO₃

**Fig. 3:** Huey tests (HNO₃ 65%, boiling)
A guidance table is given in Fig. 4, showing the diversity of solutions applied in nitric acid media.

![Guide Table for the Selection of Stainless Steels for Nitric Acid Service](image)

**Fig. 4:** Guide table for the selection of stainless steels for nitric acid service

**URGENT NEEDS**

**GEMACO** offers, from stock, a complete range of products in those different urea and nitric grades in many shapes and conditions:

- Forged or rolled bars
- Pipes and tubes (for heat exchanger, condensers, strippers or regulation), seamless or welded, thin (from 0.5 mm) or heavy wall (up to 35 mm)
- Fittings such as elbows, reducers, tees, flanges, gaskets, o’lets, etc.
- Plates and sheets

**PROJECTS AND PACKAGES**

**GEMACO** supplies major quantities with mill advantages combined with flexibility by using its own material:

- To reduce delivery times for the fabrication of fittings or custom-made items
- To provide items with smaller quantities
- To offer a complete range in many shapes and conditions

**GEMACO** will be your single source for all your needs:

- Projects (new, revamping, debottlenecking, etc.)
- Shutdown
- Maintenance

**TAILOR MADE PRODUCTS**

Gemaco can provide bendings with special radius, but also complete isometrics realised according to your specifications. We are also able to deliver special fittings, welded assemblies or machined pieces according to your drawings. Gemaco also has the possibility to offer complete welded solutions for strategic, technology based equipments from approved European suppliers.
TECHNICAL AND LOGISTIC SUPPORT

All our material is produced by European mills in compliance with the quality requirements of the most well-known licensors and fabricators in the world as well as engineering companies and their sub-contractors.

We are also used to apply the most common rules of Vd TÜV Blatt, ASTM/ASME norms and codes. We can provide you a wide range of services such as:

- Technical help regarding corrosion, forming, welding
- Monthly progress reports
- Monitoring visits to the suppliers when required (Kick-off meetings, Witness/hold points, etc.)
- Easy follow up and traceability of each item with linked heat numbers, certificates, producer’s names, etc. by digital archiving

CONTRACTOR SERVICES

With Gemaco, your high-pressure material procurement is all in one hand. Gemaco’s commitment includes management and coordination of all the sub-suppliers. Gemaco is the single point of responsibility, the spider between end-user, engineering, sub-contractor and producers.

Our warehouse is the single place for final inspection, packing and expedition, which eases final inspectors’ work. Gemaco also performs internal testing and additional controls to a mill’s inspection: visual and dimensional inspection, PMI, wall thickness measurement with US Testing, ferrite level measurement, etc.

Marking and tagging are realized according to your instructions.

The complete range of products available in Gemaco’s stock enables a real flexibility during projects procurement: our customers have the possibility to add, decrease or modify initial quantities required. This allows us to avoid undesirable stocks at the plant or shortages.

CONCLUSIONS

Gemaco provides expertise, efficiency, flexibility and reactivity, which offers to our customers less stress and more financial advantage.

We rely on performance: Higher quality for less maintenance.

Gemaco provides reliable solutions contributing to cost reduction.

Therefore GEMACO is proposing PRICE®: Professional Reliable Intelligent Customized Execution.

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