

Using corrosion resistant stainless steels to improve reliability in Urea & Nitric Acid Plant

Jean-Marc Sluyters
GEMACO S.A.
Herstal, Belgium

Summary

A presentation on using corrosion to improve reliability in Urea & Nitric Acid Plant. The role played by strategic equipment from experienced suppliers and technical support in saving time, stress and money.

This paper has been presented during the Asian Nitrogen & Syngas Conference 2013 in Singapore.

Using corrosion resistant stainless steels to improve reliability in Urea & Nitric Acid Plant

JEAN-MARC SLUYTERS

GEMACO S.A.

Herstal, Belgium

A presentation on using corrosion to improve reliability in Urea & Nitric Acid Plant. The role played by strategic equipment from experienced suppliers and technical support in saving time, stress and money

INTRODUCTION

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

Urea and Nitric Acid Plants are prone to various corrosion phenomena depending on the process, the concentration, the temperature, the composition of the gas itself, etc.

We should consider that the role of impurities and process variables such as oxidizing impurities in nitric media are generally as important as the nominal composition. In all cases the chlorides or halogen contents are also disturbing.

Therefore special austenitic stainless steels with specific requirements have been developed. Experience has proven that applying inferior materials was an attractive solution, standard, easier to find, cheaper, but not reliable and leading sometimes to safety risks and/or unplanned shut downs.

If most of the problems can be anticipated by regular maintenance, some issues can occur unexpectedly. Such situations lead to an indefinite time during which the plant is out of operation, not producing but also sometimes impacting the downstream industries.

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 bars) and high temperatures (up to 200°C) requires special stainless steel grades such as 316 L UG and/or 25.22.2 (WNR.1.4465/1.4466 – UNS S 31050).

In order to guarantee the lifetime of their installations, specialized licensors like Stamicarbon/Tecnimont, Saipem (formerly Snamprogetti), Toyo and Urea Casale, have developed their own specifications regarding the chemical composition, the micrographic structure, the mechanical properties and the corrosion resistance (Huey Tests) of the stainless steels.

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

Also called 316 L 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 Nitrogen additions. Also, the ferrite level of this particular grade is set to maximum 0,6%. These modifications aim to improve 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 and Silicon contents are low while Chromium and Nickel have respective levels of 25% and 22%. Moreover, Nitrogen is added to this chemical composition, which enables to stabilize and strengthen the austenitic phase.

As for 316L UG, the maximum level acceptable for Ferrite is 0,6%. The grade 310MoLN is a fully austenitic stainless steel free of inter-metallic phases as intergranular carbide precipitations, which affect drastically the corrosion resistance properties in urea solutions. This alloy is designed to improve corrosion resistance properties in urea carbamate environments such as for example high pressure strippers.

Both grades are mainly used for HP stripper, condenser, reactor, scrubber and piping connections

NITRIC ACID

Depending on its concentration and temperature, Nitric Acid (HNO₃) may require special stainless steel grades with low Molybdenum contents.

304L

304L should be without any trace of Mo; we need to proceed with destructive testing to check the chemical composition. Therefore difficult to find from stock. It can be produced but only in big quantities – complete charge.

WNR.1.4361 – UNS S 30600- URANUS S 1 ® (chemical composition: 18% Cr – 15 % Ni - 4 % Si).

In concentrated nitric oleum solutions (98 %) at high temperatures, the addition of 4 % Silicon to austenitic stainless steels like 304 L creates a silicate protection lay that favourably influences the passive resistance to intergranular corrosion. This effect is clearly visible on Fig. 1, where this grade exhibits a unique behaviour compared to all other stainless steels.

WNR.1.4335 - 310L NAG (Nitric Acid Grade) – UNS S 31002 - URANUS 65[®] - 2RE10[®]

In boiling Nitric Acid solutions (with less than ± 70 % concentration), the best results are obtained with high chromium grades. With a Chromium content of 25%, this grade outperforms 304L in boiling 65% acid. Its low Carbon and Phosphorus as well as its Silicon inferior to 0.3 % help to keep a more stable austenite microstructure, free of intermetallic or carbide precipitations and improve intergranular corrosion resistance and phase stability (Fig. 1 and 2). To maintain the austenitic structure, the Nickel is also increased to around 20%.

The following graphics (from Arcelor Mittal), Fig. 1,2,3 will 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.

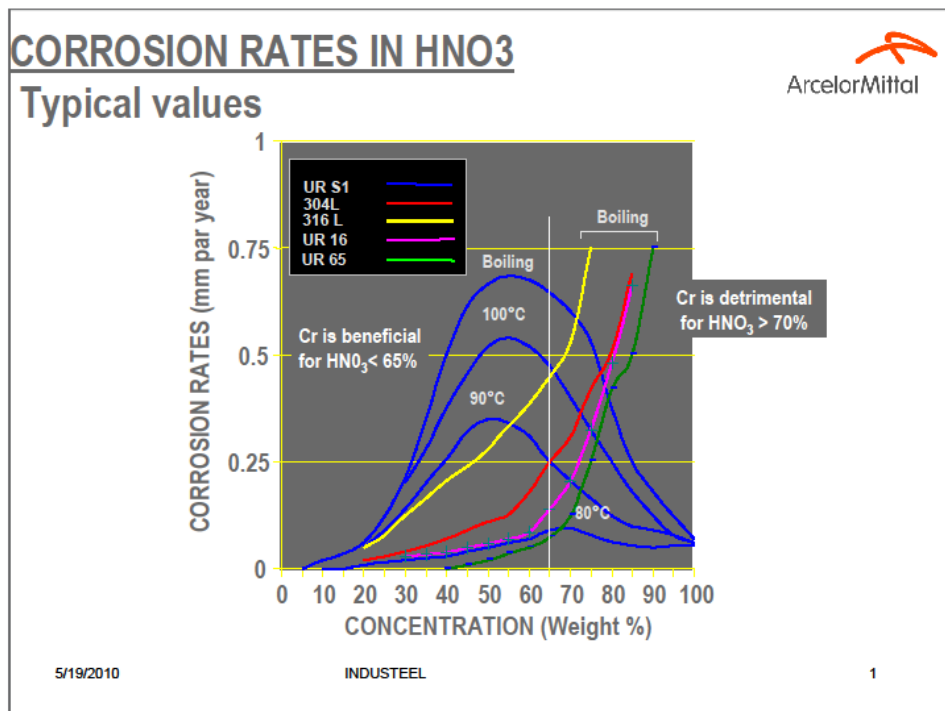


Fig. 1 Corrosion rates in HNO₃

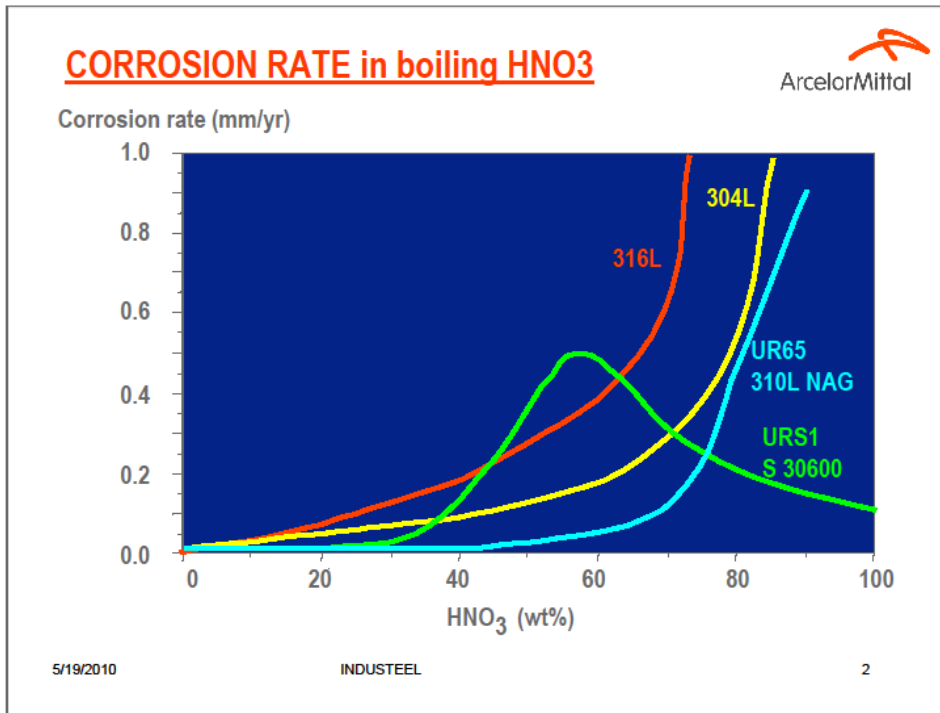


Fig. 2 Corrosion rate in boiling HNO₃

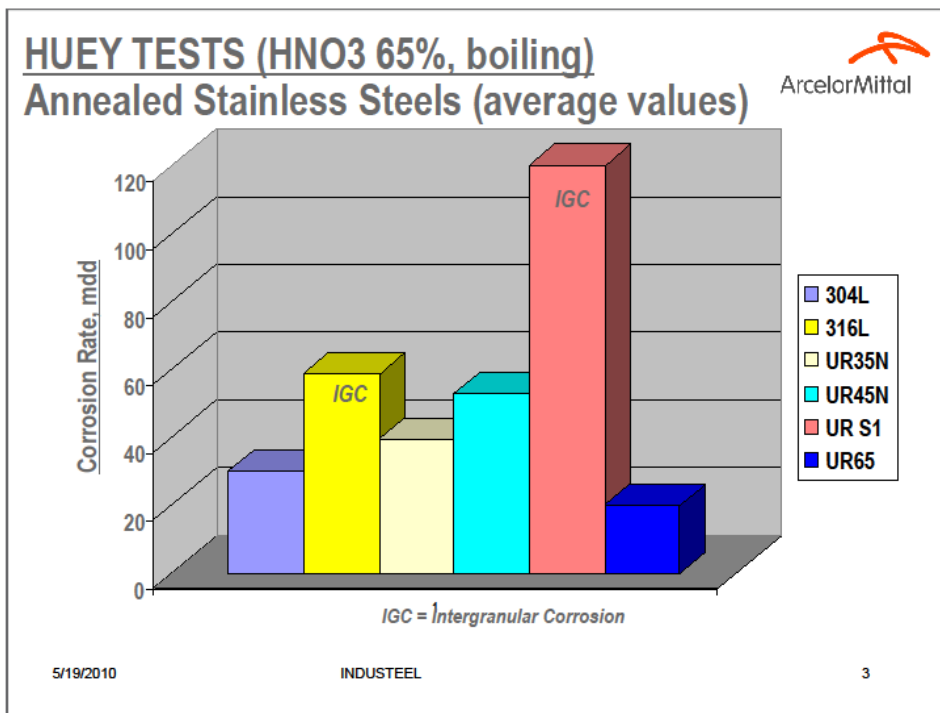


Fig.3 Huey Tests (HNO₃ 65%, boiling)

A guide 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			
	< 50 %	50-70 %	>70%
PURE NITRIC ACID T = 60°C	304 L	UR 16 UR 65	UR S1
PURE NITRIC ACID BOILING	UR 16	UR 65	UR S1
NITRIC ACID + OXIDIZING IMPURITIES	UR S1 (up to 30% Boiling)	UR 65	UR S1 (depending on Redox)
NITRIC ACID + FLUORIDES	UR 65	UR 65	
NITRIC ACID + CHLORIDES	UR B66 UR 25.22.2	UR 65 UR 25.22.2	

5/19/2010 INDUSTRIEL 4

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 GRADES in many shapes and conditions:

- Raw material (slabs, billets, bars) for the production of plates & sheets, pipes and forgings
- Forged or rolled bars
- Pipes and tubes (for heat exchanger, condensers, strippers or regulation), seamless or welded, thin or heavy wall. Diameters from 1/8" up to 8" are available, bigger sizes can be produced shortly
- Fittings such as elbows, reducers, tees, flanges, gaskets, o'lets, etc.
- Plates and sheets (up to 52 mm – 2")

PROJECTS AND PACKAGES

- GEMACO covers a complete range in many shapes & conditions, offering a single source of supply and combining mill advantages with stock flexibility.
- We can use our stock material to:
 - o Anticipate the manufacturing of fittings or flanges during the mill production of pipes or plates
 - o Provide items in small quantities
 - o Add, decrease or modify initial quantities (no delay, no stock surplus)
 - o Reduce the delivery time
 - o Deliver spare parts after erection
- GEMACO will be your single source for all your needs:
 - o Projects (new, revamping, debottlenecking, etc.)
 - o Shutdown & Maintenance
 - o Refurbishment

TAILOR MADE PRODUCTS

Gemaco can provide bendings with special radius, machined pieces, isometrics realised according to your specifications and drawings or special fittings. Gemaco offers global 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 used to apply the most common rules of Vd TÜV Blatt, ASTM/ASME, EN norms and codes.

We can provide you a wide range of services such as:

- Technical help regarding corrosion, forming, welding
- Workshop possibilities for PWHT, pickling & passivation
- 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 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-contractors 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 mill's inspection: visual and dimensional, PMI, US wall thickness measurement to guarantee the minimum required values after bending, Ferrite level or Roughness measurement, etc.

Marking and tagging are realized according to your instructions.

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.

I know it's prohibited but I will conclude by speaking about PRICE ©, at least our definition:

- Professional
- Reliable
- Intelligent
- Customized
- Execution

ACKNOWLEDGEMENTS

I would like to thank Pierre Soullignac (now retired) from Arcelor Mittal, Mark Brouwer from Urea Knowhow, Giel Notten and the GEMACO team for their assistance, support & collaboration.

References

Abu qir, alexfert, borealis, areva, basf, borsodchem, fauji, fertil, g.n.f.c, gpic, hindustan organic chemicals, larsen & turbo, omifco, petronas, qafco, saipem, skw piesteriz, urea casale, yara, ...