



RECONNECT

SYMPOSIUM 2022

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Experiences and achievements with new grades of Safurex®

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Agenda

- Importance of M.O.C in urea synthesis
- New generations Safurex®
- Qualification process
- Approval from code bodies
- Field exposure
- Evaluation of first installed Safurex® HEX tube
- Achievements
- Summary

Importance of stainless steels in urea synthesis

- In urea synthesis, the intermediate product of ammonium carbamate is considered as a strong acid.

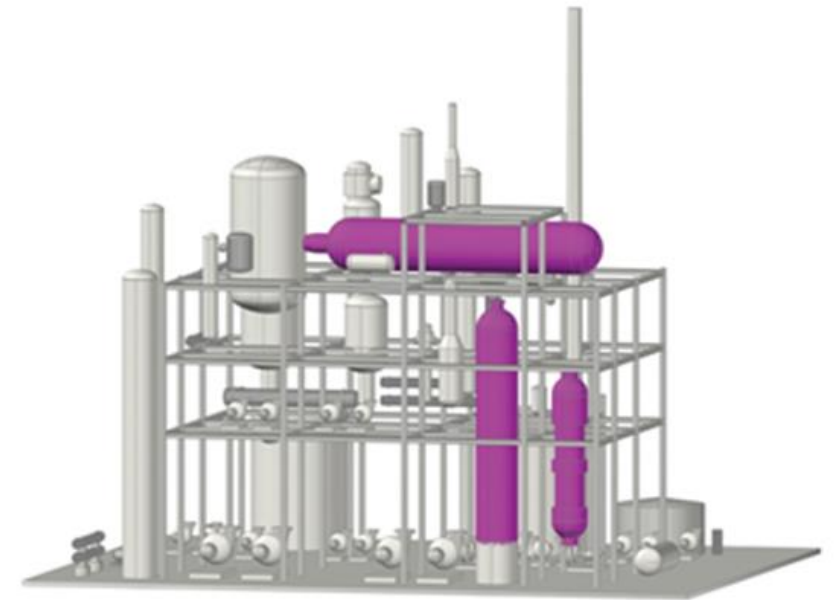


Importance of stainless steels in urea synthesis

- Special attention must be paid to the selection of material of construction:
- Commercial production of urea made possible because:
 - **1950's**: Passivation of 316L Urea grade (BC.01) stainless steel with air.
 - **1960's**: Development of X2CrNiMoN25-22-2 (BC.05) after introduction of CO₂ stripping process. More corrosion resistant material was required for HP stripper.

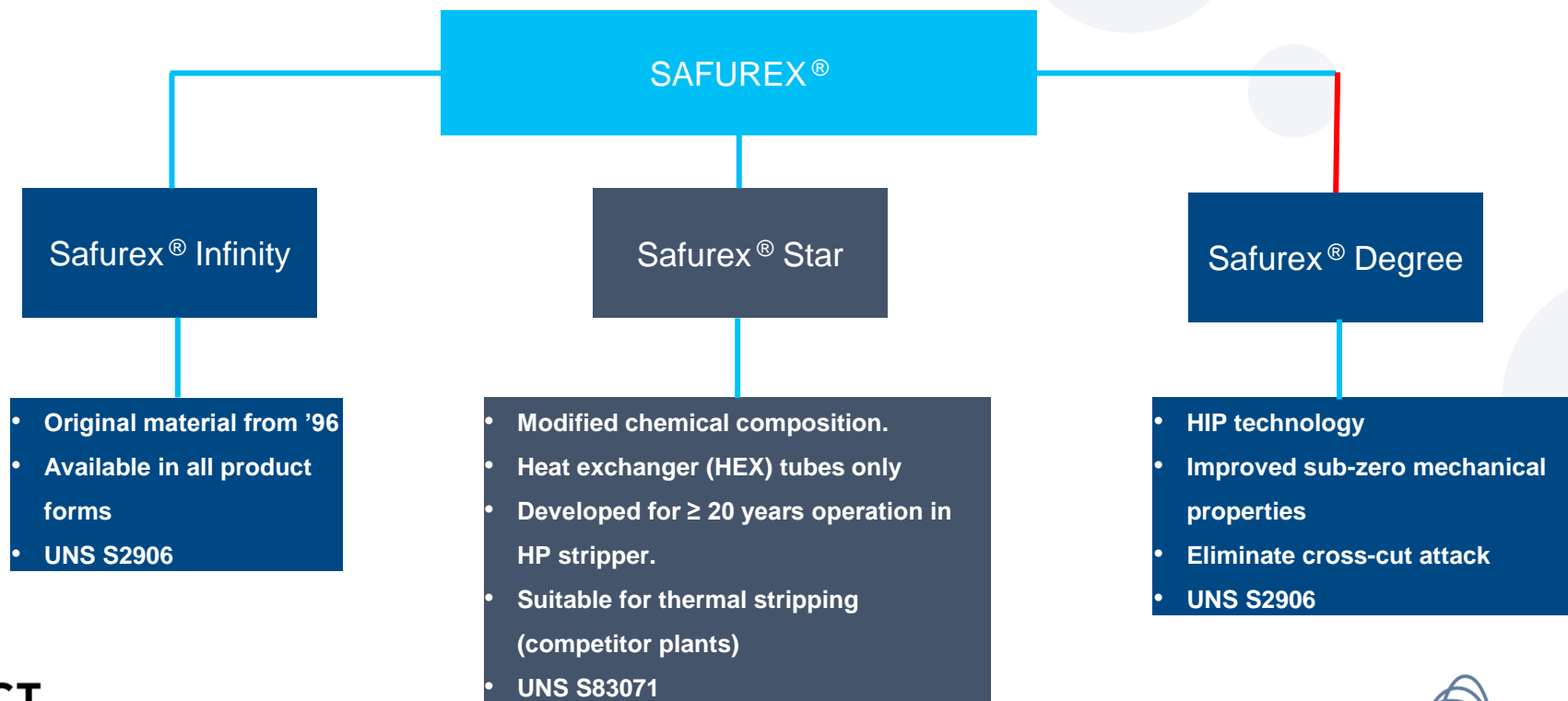
Importance of M.O.C in urea synthesis

- Introduction of Safurex® in 1996 represented a huge step forward in stainless steels used for urea synthesis equipment and piping.
 - Resistance to Chloride Stress Corrosion Cracking (SCC)
 - Passive corrosion rates equal to or better than BC.05
 - Higher mechanical properties
 - Improved weld-ability
 - Enable synthesis of urea with low oxygen



New generation on Safurex® grades

Continuous drive for innovation means the Safurex® brand has expanded. Two new grades introduced in 2016.



New generation on Safurex® grades

- New grades of Safurex have been developed at higher temperatures than in Stamicarbon plants.
- The results is materials with:
 - Improved passive corrosion rate in HP Stripper tubes.
 - Improved mechanical properties (improved toughness at sub-zero temperatures).
 - Elimination of cross-cut attack from cross-cut surfaces.
 - Ability to function in competitor plants, which operate at higher temperatures than can be found in Stamicarbon plants (thermal stripping plants).

Qualification process

- New grades have been qualified for production in collaboration with Sandvik and HP equipment manufacturers.
- Homogeneity testing of Safurex Star HEX tubes. More than 11000 tubes produced, all have a uniform microstructure across the length of HEX tube.
- Metallographic examination of tube to tubesheet welds. Welds are all free from:
 - Cracks
 - Lack of fusion
 - Porosities
 - Slag inclusions
 - Non-metallic inclusions
- Pull out test (EN ISO 15614-8) proved mechanical integrity of Safurex Star HEX tubes welded to tubesheet block. Failure occurred outside on the weld connection.

Approval from code bodies

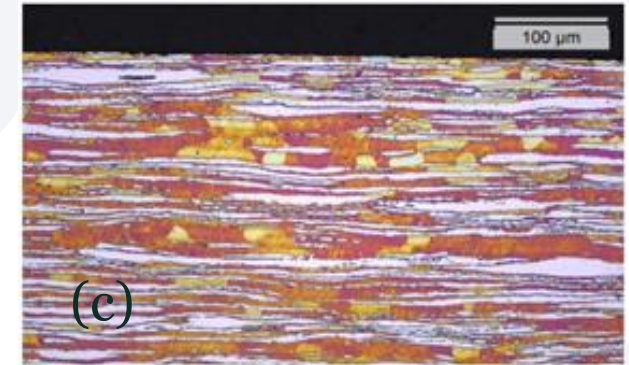
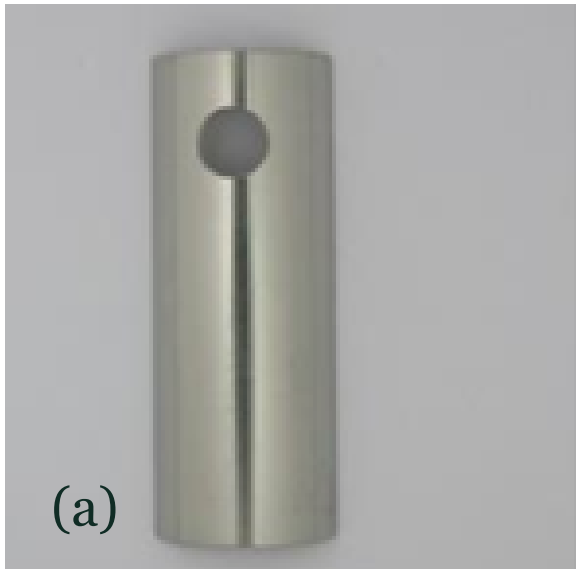
- **Safurex® Star: UNS number S83071:**
 - Included in ASTM product standards; A789 (tubes for general service) and A790 (pipes).
 - ASME code case approved with case number 2914.
 - TÜV Nord pre-approval for Particular Materials Appraisal (pre-PMA). HP equipment can be designed and produced according to AD 2000 and the Pressure Equipment Directive 2014/68/EU (PED).
- **Safurex® Degree UNS number S2906:**
 - ASTM A988.
 - ASME code case approved with number 2840.
 - Pre-PMA in place for vessels to be designed and built according to European standards for HP equipment.

Field exposure

Laboratory results have been verified in an operating plant

- Safurex® Star and Safurex® Degree materials have been exposed in both a urea and melamine plant for 1 year, in collaboration with a client.
 - Test coupons in HP stripper
 - Test coupons also placed in melamine plant
- Corrosion rates of test coupons after one year of exposure were ≤ 0.05 mm/y.
 - Safurex® Star performing 20 % better than reference Safurex® Infinity material.
 - Minimum Allowable Wall Thickness (MAWT) for Safurex® Star tubes is 0.75 mm
- Results are confirmation of the corrosion resistance of the Safurex® Star and Safurex® Degree materials.

Field exposure Safurex® star



- a) Safurex ® Star tube material before exposure in urea plant.
- b) After exposure in urea plant.
- c) Microstructure the Star HEX tube barely showing any signs of attack after one year of exposure.

Field exposure Safurex® degree

- The service life of Safurex® Infinity liquid dividers though acceptable, is shorter than targeted due to:
 - Increasing liquid divider hole diameter (influences the liquid height above the top tubesheet)
 - Severe knife edge attack in the Heat Affected Zones (HAZ)
- Liquid dividers made from bar, pipe, tube material, suffer from crosscut end attack as a result of directional microstructure.
- Several welds in a small part, destroys the corrosion resistant structure of the super duplex material.

Field exposure Safurex® degree



Selective and knife edge attack, and enlargement of the liquid divider hole diameter.

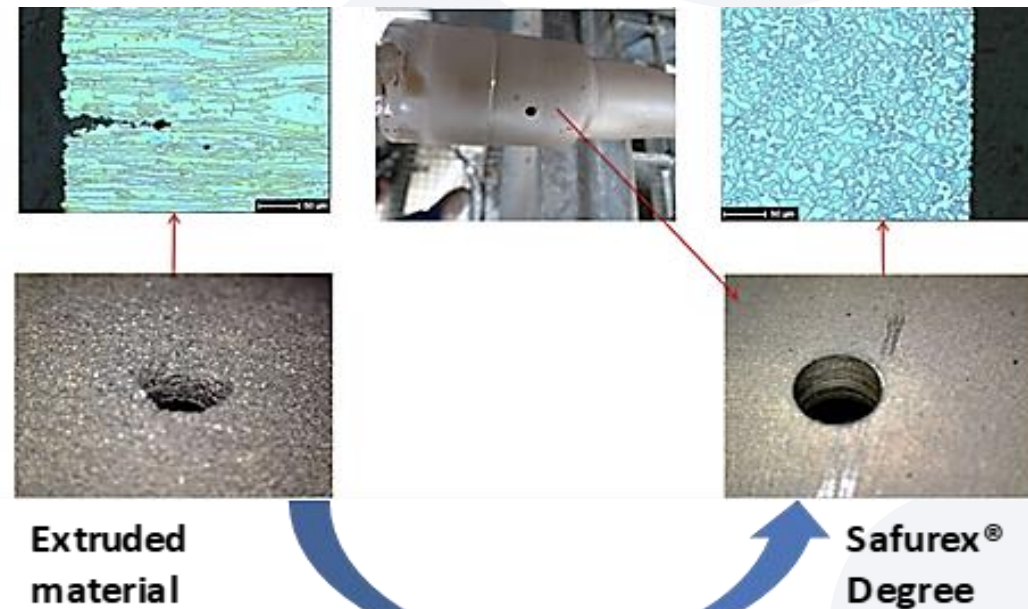
Solutions

- Make microstructure uniform and very fine to eliminate cross cut attack.
- This is achieved by HIP (Safurex® Degree).
- Reduce the number of welds on liquid divider to 1 seal weld.
- Tight quality control on the seal weld.

Field exposure



Safurex[®] Degree liquid divider produced and installed in HP stripper.



After 8 years of service, machining groves still visible!
No evidence of selective / cross cut attack in Safurex[®] Degree material.

Evaluation of first installed Safurex® HEX tube

- Three Safurex ® Infinity HEX tubes were placed in a BC.05 HP stripper commissioned in 1998 (pilot tubes).
- Last of these tubes removed in 2019 after 19.2 years on stream time. It was examined together with a BC.05 HEX tube from the same equipment.

	BC.05	BE.06	Comments
Corrosion rate (mm/yr)	0.083	0.078	-6 %
Expected life (years)	24	28.2	+18 %
Expected life corrected (years)	20.5	28.2	+37.5 %

- MAWT of BC.05 and BE.06 are 1.35 mm and 0.8 mm respectively.

Achievements

- No reports of active corrosion or catastrophic failure!
- Low oxygen requirement: 2 plants using Safurex® Infinity are running to date with 0.1 vol % of oxygen, without corrosion issues.
 - Also, upsets leading to loss of passivation air for up to several months. No active corrosion reported in Safurex® Infinity HEX tubes.
- Safurex® has proven to be immune to SIIC and SCC.
- > 250 equipment operating in Stamicarbon and competitor plants.
- 316L UG (BC.01) and X2CrNiMoN 25-22-2 (BC.05) pipelines have been replaced with Safurex® piping to extend life.

Achievements

- In 2018 Stamicarbon made Safurex® Star heat exchanger tubes and Safurex® Degree the mandatory materials of construction for HP stripper HEX tubes and liquid dividers.

Plant Location	Equipment	Status
The Netherlands	HP Stripper	In operation
China	HP Stripper	In operation
Kingdom of Saudi Arabia	HP Stripper	In operation
Russia	HP Stripper	In operation
Egypt	HP Stripper	Under manufacturing
Kingdom of Saudi Arabia	HP Stripper	Under manufacturing
Russia (multiple)	HP Stripper	Under manufacturing
Turkey	HP Stripper	Under manufacturing
China	HP Stripper	Under manufacturing
Kingdom of Saudi Arabia	HP Stripper	Under manufacturing
India	HP Stripper	Under engineering
United States	HP Stripper	Under manufacturing

Achievements

Plant Location	Equipment	Status
The Netherlands	HP Stripper	In operation
Germany	HP Stripper	In operation
China	HP Stripper	In operation
Kingdom of Saudi Arabia	HP Stripper	In operation
Pakistan	HP Stripper	In operation
China	HP Stripper	In operation
Qatar	HP Stripper	In operation
Kingdom of Saudi Arabia	HP Stripper	In operation
Qatar	HP Stripper	In operation
Russia	HP Stripper	Manufacturing
Egypt	HP Stripper	Manufacturing
Russia	HP Stripper	Manufacturing
United States (multiple)	HP Stripper	Manufacturing
Egypt (multiple)	HP Stripper	Manufacturing
Russia (multiple)	HP Stripper	Manufacturing
India	HP Stripper	Manufacturing
Total liquid dividers		53,496

The plant locations and total number of Safurex® Degree liquid dividers in operation or being manufactured. Some of these are replacement liquid dividers installed in competitor plants.

Achievements



Radar level measurement system made from Safurex® Degree

- Safurex® Degree is also used to manufacture high pressure Safety and check valves and ejectors when sub zero Minimum Design Metal Temperatures (MDMT) are required
- Radar level measurement systems are also made using the same production route. The large cross-cut surfaces benefit from the corrosion resistance offered by HIP'ing

Summary

- Stamicarbon and Sandvik have successfully expanded the Safurex® product line of corrosion resistant super duplex stainless steel with Safurex® Star and Safurex® Degree grades.
- These grades have improved corrosion resistance and superior mechanical properties.
- The new grades have exposed in industrial urea and melamine plants (Stamicarbon and competitor plants), with excellent results.
- Safurex® Star is currently specified for use as HEX tubes in all new HP strippers.
- Safurex® Degree is currently specified for fabricating liquid dividers. Also used to fabricate big bodied valves, ejectors and radar level measurement systems.

Summary

- Safurex® Infinity is used for fabrication of equipment in all remaining synthesis equipment.
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- > 11000 Safurex® Star HEX tubes installed in plants around the world.
- > 50000 pieces of Safurex® Degree liquid dividers are also in service in HP strippers running on both Stamicarbon and competitor technologies.

Questions?



Thank you!