

CRU

Middle East Nitrogen + Syngas 2019

27-29 October • Sheraton Oman, Muscat, Oman

REPAIR OF A HP SCRUBBER DAMAGED BY CORROSION

Stamicarbon Workshop
Middle East Nitrogen +
Syngas 2019

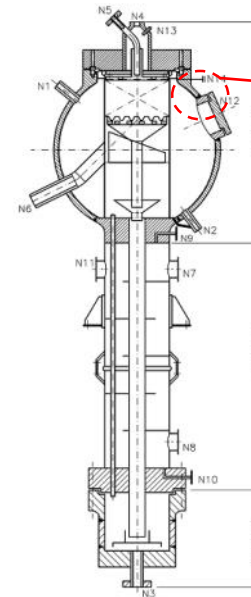
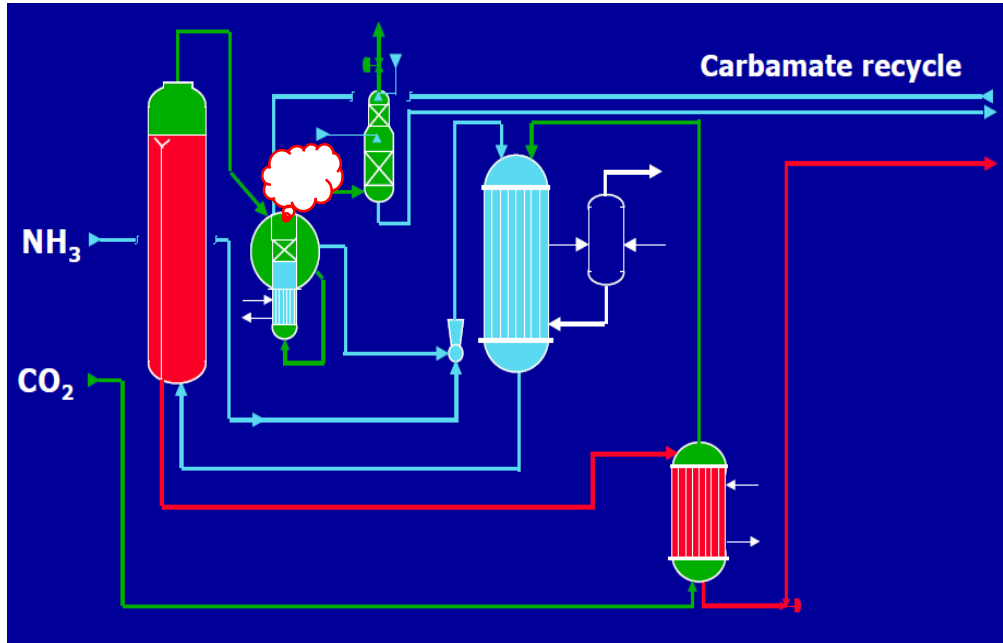
Alex Scheerder, Stamicarbon, The
Netherlands
October 2019

AGENDA

1. Leak in HP Scrubber
2. Why is ammonium carbamate highly corrosive?
3. How to protect pressure vessel?
4. Case history
5. Which damage mechanisms occurred?
6. How to repair?
7. How to avoid this mishap?

LEAK IN HP SCRUBBER

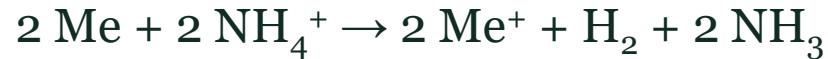
February 2018: leak to atmosphere observed in HP Scrubber sphere



Why is ammonium carbamate highly corrosive?

CORROSIVENESS AMMONIUM CARBAMATE

- Strong Brønsted Acid solution (pH < 0 !!).
 - Proton donor is the Ammonium ion



- Corrosion C-steel in Ammonium Carbamate: > 500 mm/y

How to protect steel pressure vessel for corrosion?

HOW TO PROTECT C-STEEL PRESSURE VESSEL

- Stainless Steel barrier
 - Weld overlay
 - Loose liner (leak detection system)
 - Austenitic SS-steel (316L UG and X2CrNiMo25-22-2): passivation air needed
 - Passive corrosion rates: 0.05 ~ 0.1 mm/y (active: > 30 mm/y)
 - Take care of weld quality



- Catastrophic failure urea reactor (100 mtpd)
- Unnoticed leakage through stainless steel barrier
- Affected the carbon-steel pressure shell
- Break-Before-Leak Scenario

CASE HISTORY

1. Loss of containment
2. Corrosion of stainless steel barrier unnoticed by leak detection system
3. Unnoticed corrosion of pressure shell
4. 20MnMoNi45 carbon-steel: 53 mm
5. Near miss: Leak-Before-Break Scenario



Present Leak detection system

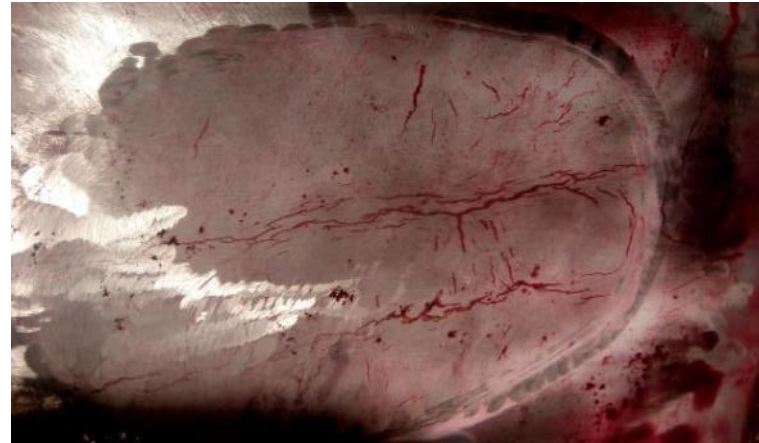
CASE HISTORY

Severe corrosion of stainless steel liner: 316L UG nominal 9 mm thickness



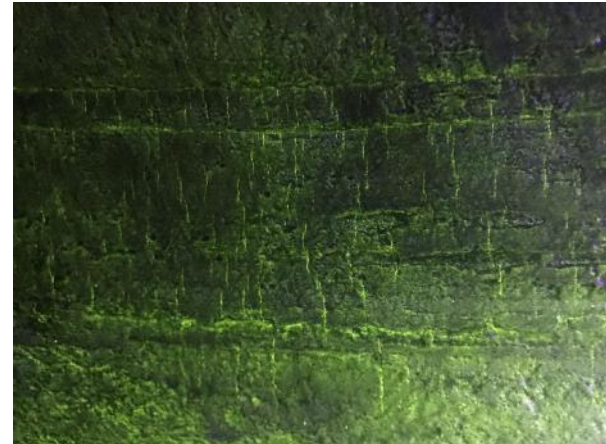
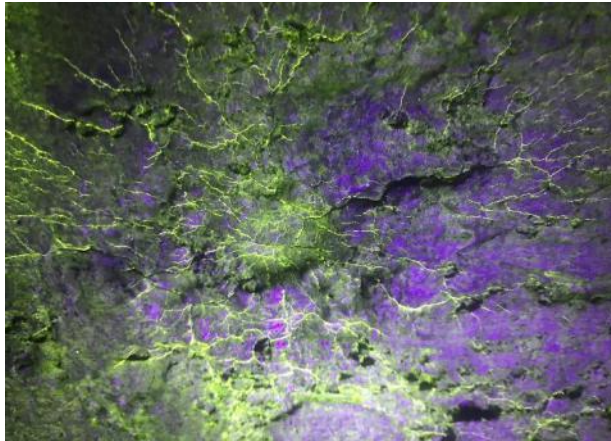
CASE HISTORY

- Liner severely cracked
- Many cracks through wall
- Ammonium-carbamate leaking behind liner



CASE HISTORY

- Carbon-steel pressure shell
- Severely corroded by ammonium-carbamate
- Local wall thinning and Stress corrosion cracks



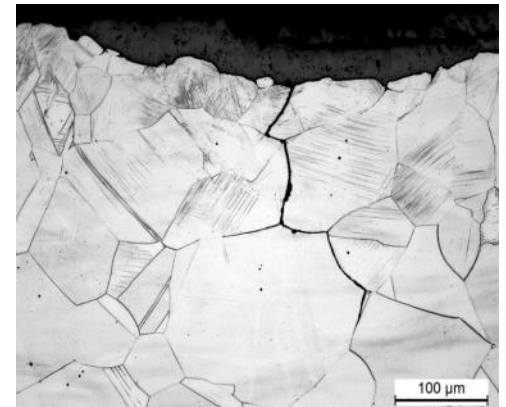
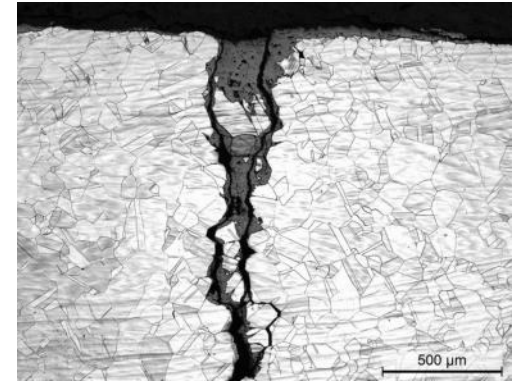
What are the corrosion mechanisms?

- Liner?
- Carbon Steel?

FAILURE ANALYSIS

Liner damage:

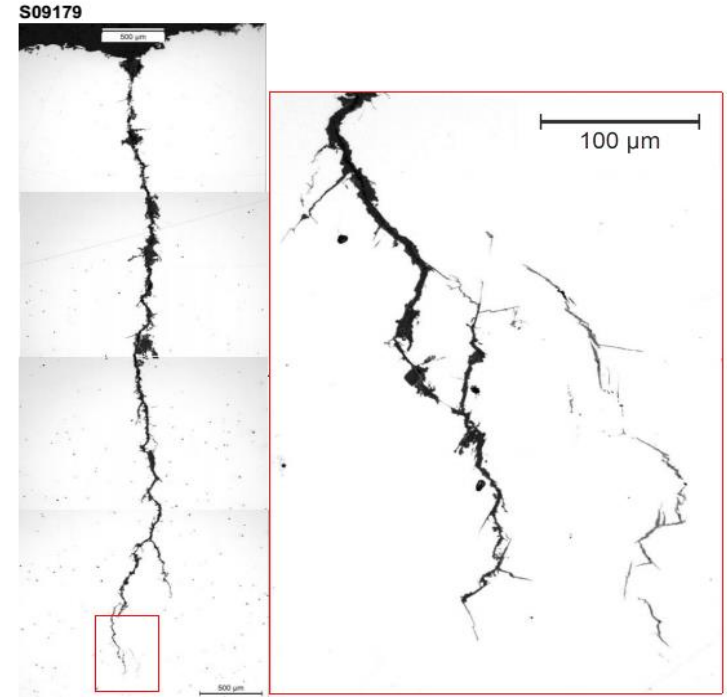
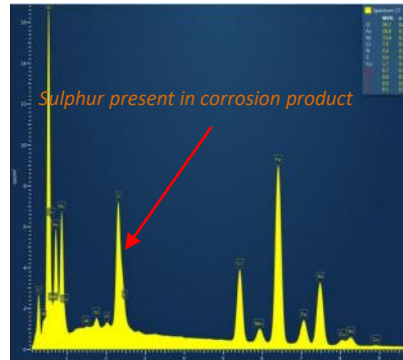
- Strain Induced Intergranular Cracking
- Condensation of $\text{NH}_3/\text{CO}_2/\text{H}_2\text{O}$ gas
 - Hot off gas reactor
 - Insufficient insulation - tracing
- Plastic deformation of liner
 - Bending of plate
 - Temperature – pressure cycles
 - Poor fit
 - Large grain size (ASTM 2.5-3)
- Contaminants such as Sulphur
- Slowly propagating cracks



FAILURE ANALYSIS

Carbon-steel pressure shell:

- Wall thinning carbamate corrosion
- Hydrogen Induced Stress Corrosion Cracking (HISCC)
- Hydrogen developed by cathodic corrosion reaction
- Steel metallurgy (too high Carbon Equivalence)
- Sulphur enhances hydrogen uptake
- Slowly propagation of cracks



How to repair?

- Liner?
- Carbon Steel?

REPAIR

- Phase 1: Remove old liner plates:
- Phase 2 : Carbon steel shell repair by welding
- Phase 3 : Metal Epoxy Component (Belzona application)
- Phase 4: Install new liner plates; improve metallurgy into X2CrNiMo25-22-2
- Phase 5 : Hydrostatic pressure test and ammonia leak test

Repair is considered temporarily

HP Scrubber will be replaced

REPAIR

Phase 1: removing old liners (16 segments)



Phase 2 : Carbon steel shell repair by welding

How to take care of hydrogen in C-steel?

REPAIR STRATEGY TO DEAL WITH HYDROGEN

Phase 2 : Carbon steel shell repair

- ❖ Care taken to outgas hydrogen (soaking)
 - Before welding
 - After welding
 - Take care to minimize welding as much as possible
- ❖ Remove all cracks by careful grinding
- ❖ Determine minimum required wall thickness (Fitness For Service assessment)
Minimum required wall thickness: 37 – 45 mm
- ❖ Repair welding until meeting minimum required thickness
- ❖ Subsequent filling with metal epoxy compound

REPAIR

Pre-heating during repair welding: 120 °C

Soaking to outgas hydrogen before and after welding: 300 °C

PWHT after welding: 540 °C



REPAIR

Grinding out cracks and repair welding

Clean & repair leak detection system

The time needed to remove all cracks approx. 11 days



REPAIR



The innovation & license company of
Maire Tecnimont



REPAIR

Phase 3 : Metal Epoxy Component (Belzona application)



REPAIR

Phase 4 : Installation new liners: 6mm X2CrNiMo25-22-2

- ❖ Welding process GTAW
- ❖ Root passes were checked by DPT , Ferrite content and soap leak test
- ❖ The time needed approx. 11 days



How to avoid this mishap?

Mitigation actions to avoid such mishap

- Reliable and robust leak detection system
 - Stamicarbon offers State-of –the Art systems
- Act immediately upon leak in the stainless steel barrier
- Apply Safurex® as protective barrier:
 - Not susceptible for SIIC:

A close-up photograph of a person's hands, wearing a blue jacket, holding a large amount of small, white, granular material. The granules are piled in the palms and fingers, with some falling away at the bottom. The background is dark and out of focus.

THANK YOU

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