Corrosion Prevention in Acid Gas Treating Units

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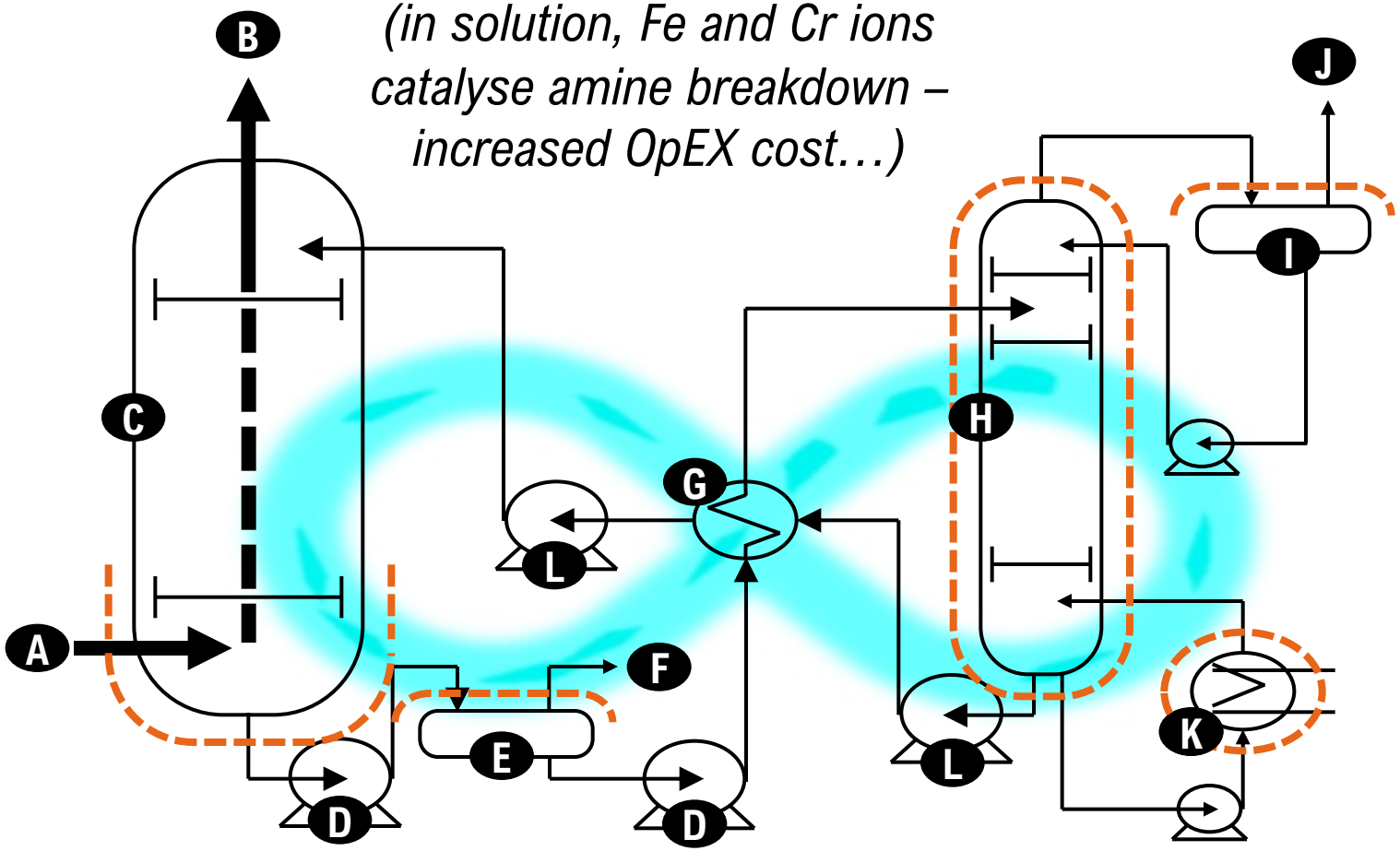
Corrosion in Acid Gas Scrubbing Cycle

(in solution, Fe and Cr ions catalyse amine breakdown – increased OpEX cost…)



- Consider an absorber / regenerator cycle used in amine based gas purification
- 'Problem' areas are highlighted as shown
- **Specialised coating** *can* help with nearly all areas

A IMPURE GAS	G MAIN HEAT EXCHANGER
B PURIFIED GAS	H REGENERATOR COLUMN
C ABSORBER COLUMN	I REFLUX ACCUMULATOR
D RICH AMINE PUMP	J ACID GAS(ES)
E 'FLASH' DRUM	K REBOILER
F 'FLASH' GAS	L LEAN AMINE PUMP

(corrosion-resistant alloys (CRAs) are required for moving parts and/or close dimensional tolerances)

Acid Gas Removal Process

- ABSORBER: Lean amine falls through rising acid gas and chemically absorbs H_2S and CO_2. Typical temperature is around 60 Celsius or lower.

- REGENERATOR: Amine-acid gas (rich amine) is heated within regenerator by reboiler to over 120 Celsius to remove acid gases. Hot lean amine recirculates and cooled before re-entering top of absorber.

- Cycle is repeated continuously.

Creating Corrosive Processes

- Hot lean amine gradually reacts with:

(a) Fe ions from carbon steel

(b) Cr ions from high chromium stainless steel

(c) Cr ions in Hastelloy metal spray.

Fe ions react with hot lean amine more quickly than Cr ions.

RESULT: Formation of amine metal ion complex

- Amine+Cr ion complex is more efficient at catalysing breakdown of amine than Amine+Fe ion complex.

RESULT: Amine is broken down into organic acids and ineffective amines.

Result of Corrosive Processes

- Amine breakdown leads to loss in efficiency of amine with reduced ability to remove acid gas.
- Reaction of amine and organic acids (acetic, oxalic and formic acids) create heat stable salts (HSS). Very corrosive.
- Galvanic corrosion from acid gas and HSS lead to deep pitting.
- Amine reaction to Fe and Cr ions leads to general wall thinning of process vessels especially under fast flow conditions.

Corrosion Issues

- Wet acid Gas = Deep pitting corrosion
- Rich Amine = Pitting Corrosion
- Hot Lean Amine = Wall Thinning
- Heat Stable Salts (HSS) = Pitting Corrosion
- H_2S = Hydrogen Induced Cracking from

Use of stainless steel equipment, hastelloy metal spray and SS cladding in parts of the amine plant will exacerbate corrosion in carbon steel sections.

Uncoated carbon steel and high chromium steels will degrade amines at faster rate.

Prevention of Undesirable Processes

- DuraPol UHT is an organic-inorganic hybrid coating resistant to amines and acid gases up to at least 150 Celsius and elevated pressures. Plus 10 year track record at Saudi Aramco and ADNOC.

- DuraPol UHT used instead of silicone sealers to effectively seal and isolate porous metal spray from amine process. Typical bond strength of metal spray with DuraPol UHT coating as sealer/top coat exceeds 40 MPa.

Note: silicone sealers are washed out immediately when exposed to amine – sour gas process environment. Result is porous metal spray leading to under film corrosion

DuraPol UHT Coating Technology

- Inorganic molecules polymerised onto multi functional organic polymers – hybridisation
- Increased crosslink density after ambient cure – high immersion chemical resistance without post cure
- Inorganic nano groups – high temperature capability
- Nano modified hybrid molecule – chemical resistance at ambient to high immersion temperatures

3rd Party Testing

Autoclave test in accorandace with NACE TM0174

H_2S ResistanceTest

1. Liquid Phase: 5% NaCl and 95% distilled water by volume at 150°C and 1000 psi
   Gas Phase: 38.8% H_2S, 6.8% CO_2, 54.4% CH_4.

Amine Resistance Test

2. Liquid Phase: 50% MDEA and 50% distilled water by volume at 150°C and 1000 psi
   Gas Phase: 2% H_2S, 9% CO_2, 89% CH_4.

3. Liquid Phase: 55% DGA and 45% distilled water by volume at 150°C and 1000 psi
   Gas Phase: 5% H_2S, 10% CO_2, 85% CH_4.

Test Results

- No softening, cracking, blistering or delamination in all tests
- EIS (Log Z, where Z is the Coating Impedance measured in ohms.cm^2) indicates very good to excellent resistance after all tests.

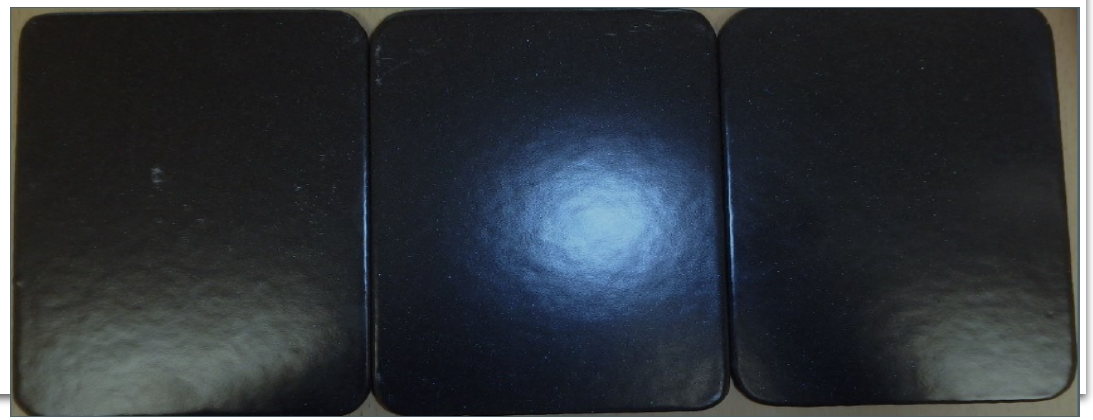
Test 1: H_2S
Pre Test EIS: 10.88
Post Test EIS: 8.98

Test 2: MDEA
Average Post Test Adhesion: 2,512 psi (Cohesive / Glue Failure)
Average Post Test EIS: 10.28 (Excellent)

Test 3: DGA
Average Post Test Adhesion: 2,287 psi (Cohesive / Glue Failure)
Average Post Test EIS: 8.81

Water Resistance

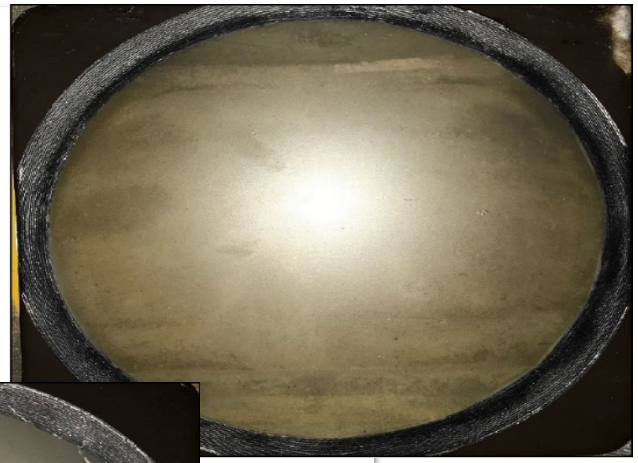
Seawater
Cathodic disbondment
-1.5V, 150°C, 1 month



RESULTS
No disbondment, no blistering, cracking or delamination

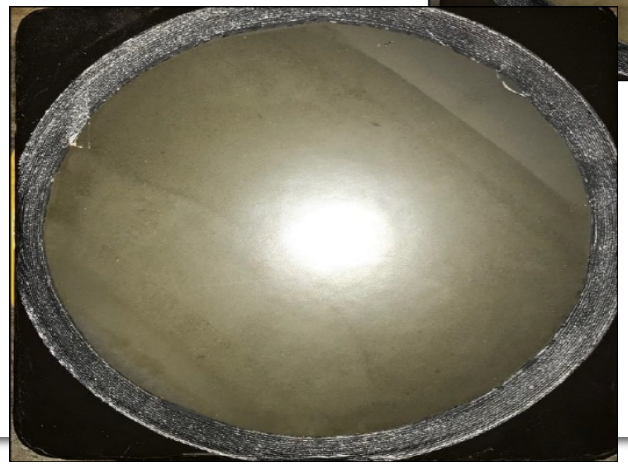
Cold wall immersion in demin water
Duration: 6 months
Temperature: 150°C

RESULTS
No change in coating except discoloration



Average EIS: Coating Impedance, Log Z (Z in ohms.cm^2)
Before: 10.97 After: 8.38

Average Adhesion:
Before: 1825 psi (GF) After: 2233 psi (GF)



Application of DuraPol UHT

Application Method

- Single component standard airless spray. Pump size: 63:1 ratio or greater.
- Internal pipe coating equipment.
- Brush

Number of Coats

- 1 coat @ 800-1000 microns
- Repair: sweep blast 1st coat and apply 2nd coat

Cure Temperature

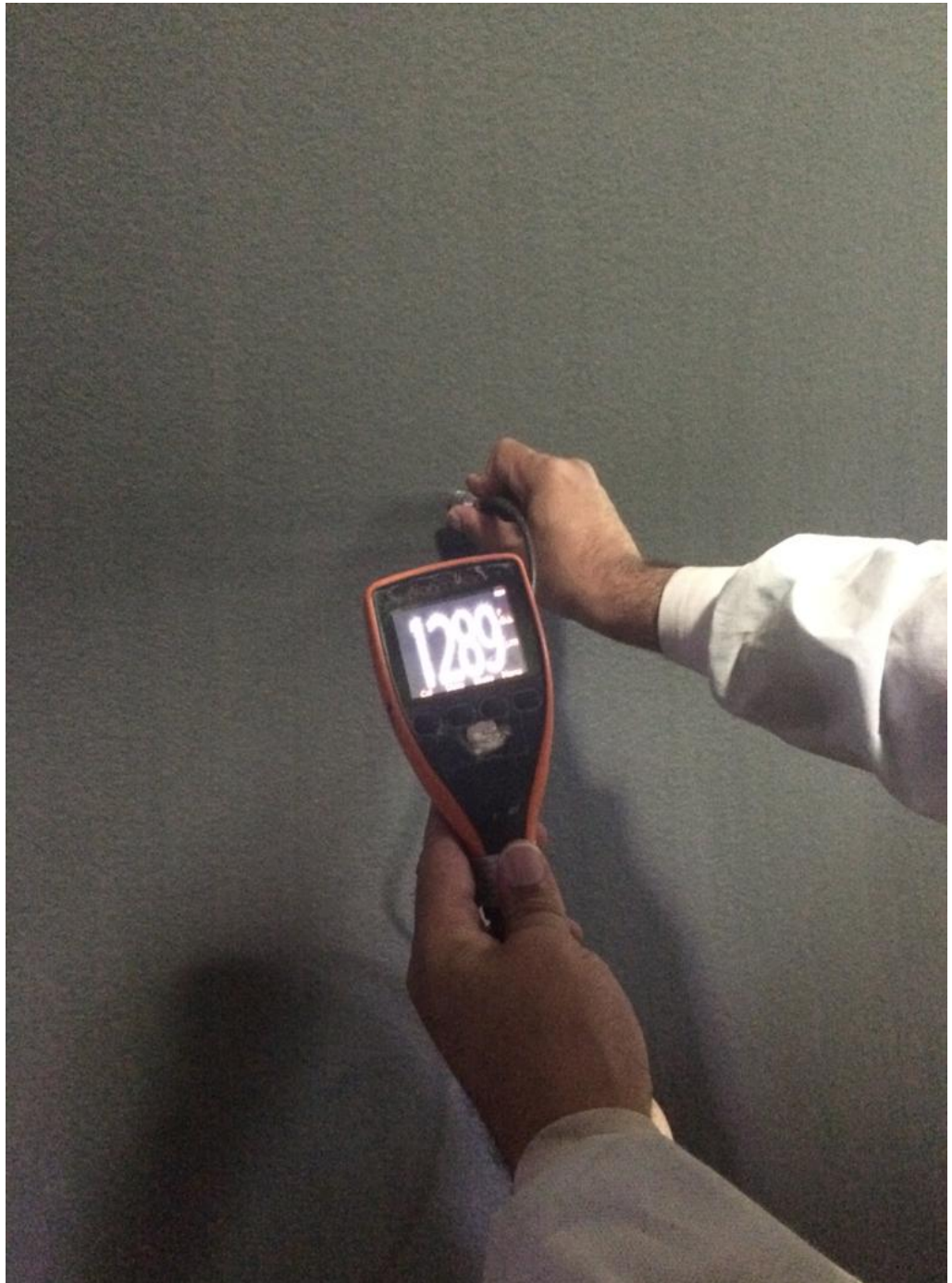
- Min > 20°C Max. < 80°C

Cure Duration

- 24 hours @ +40°C (Can use hot air)
- 3 days @ +20°C


skomesser
DTG.003

British Petroleum – Rumaila, Iraq
3 Phase Pressure Vessel: 4.5 metre Diameter x 30 m T/T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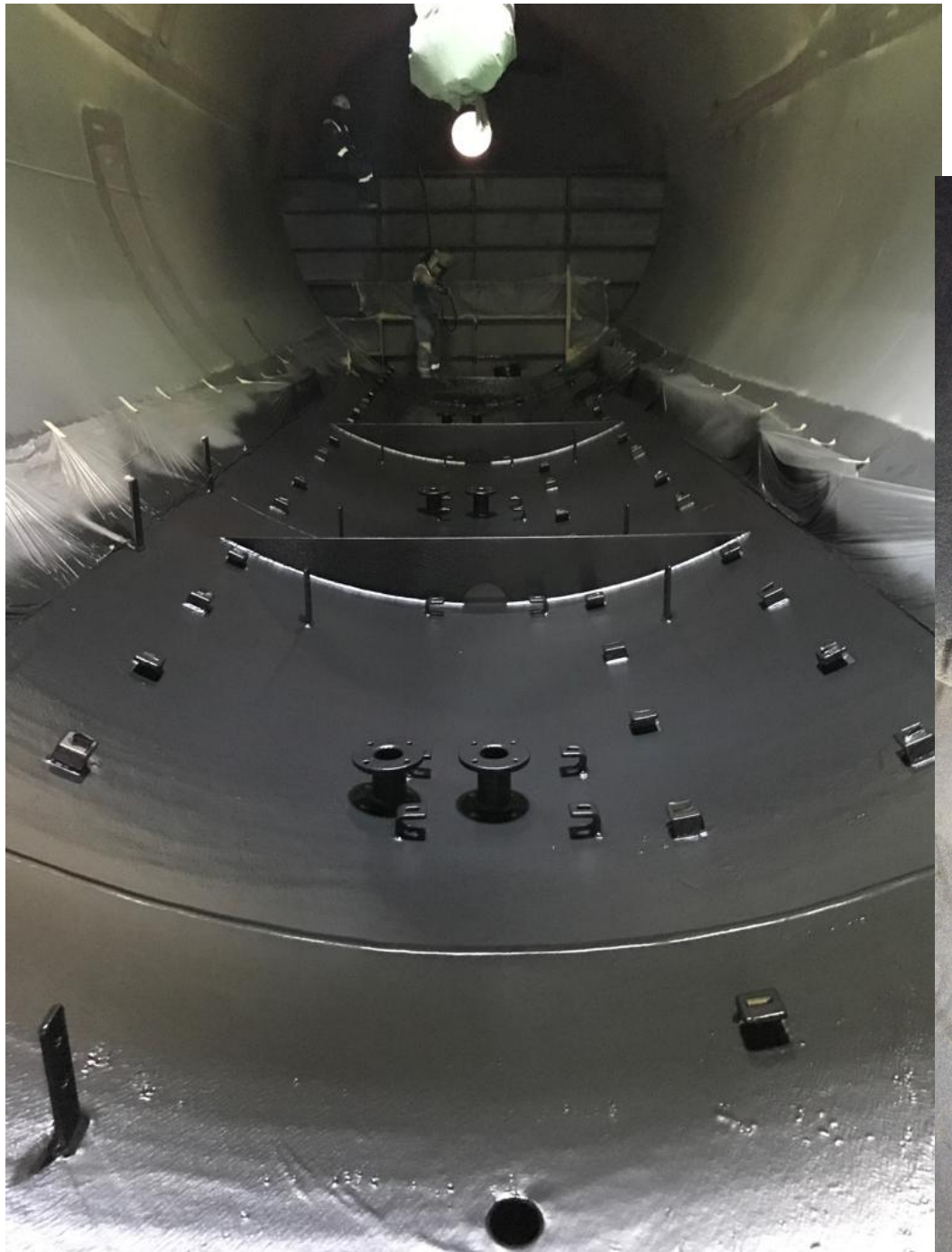
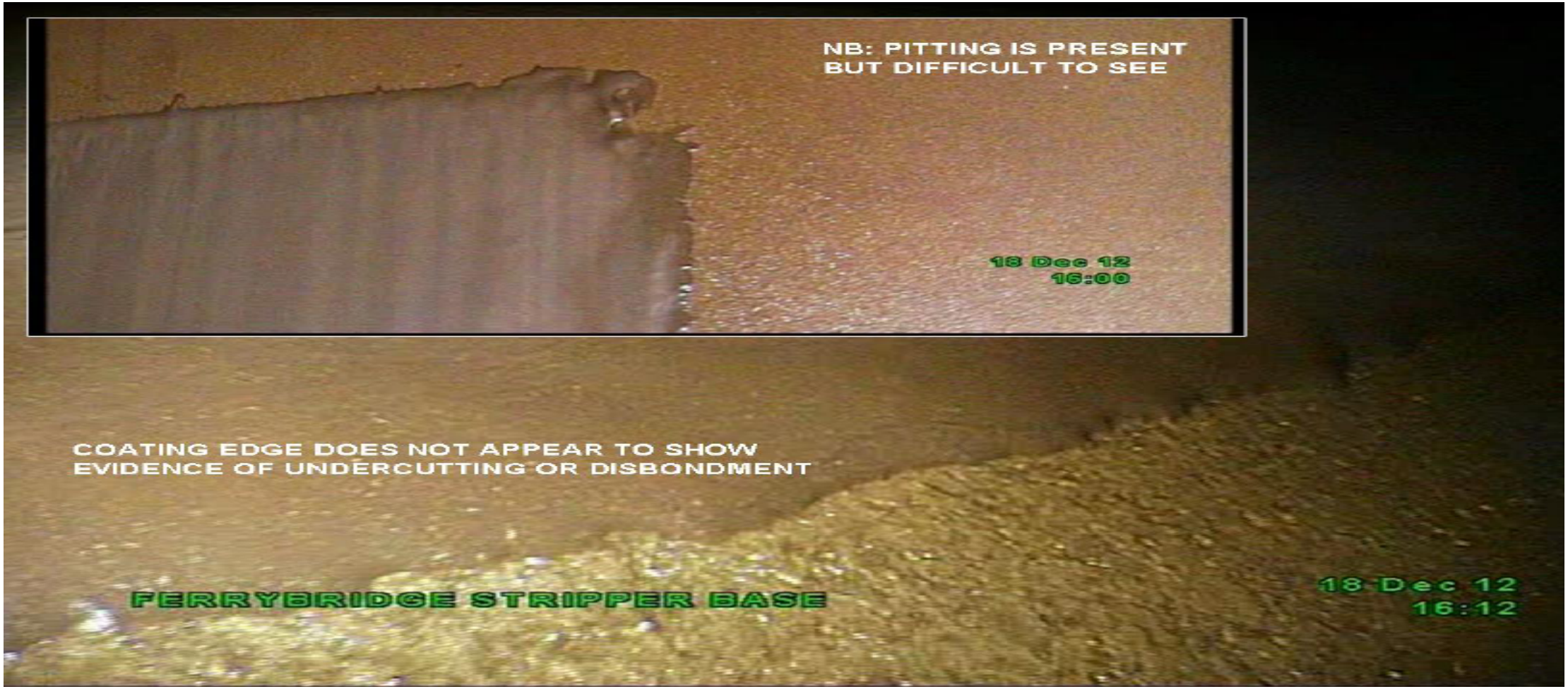


Case Study 1

Carbon Capture Pilot

316L SS Stripper Operating at 128°C in Rich MEA



Results after 1 year trial: Stainless steel has undergone pitting whereas coating shows only slight discoloration.

Case Study 2

Clean Coal Power Plant

MDEA/Sulphinol Stripper Operating at 120°C

DuraPol UHT coating in excellent condition after 5 years service

Case Study 3

Glycol Surge Drums

- Operating conditions: 99% lean TEG glycol, 37% dissolved H_2S, 86% water vapour concentration at an operating temperature of 103°C and a maximum operating pressure of 14.5 psig.

BEFORE

Vessel internal surface prior to coating. Severe metal loss and deep pitting in roof section due to deep penetrating H_2S corrosion

Case Study 4

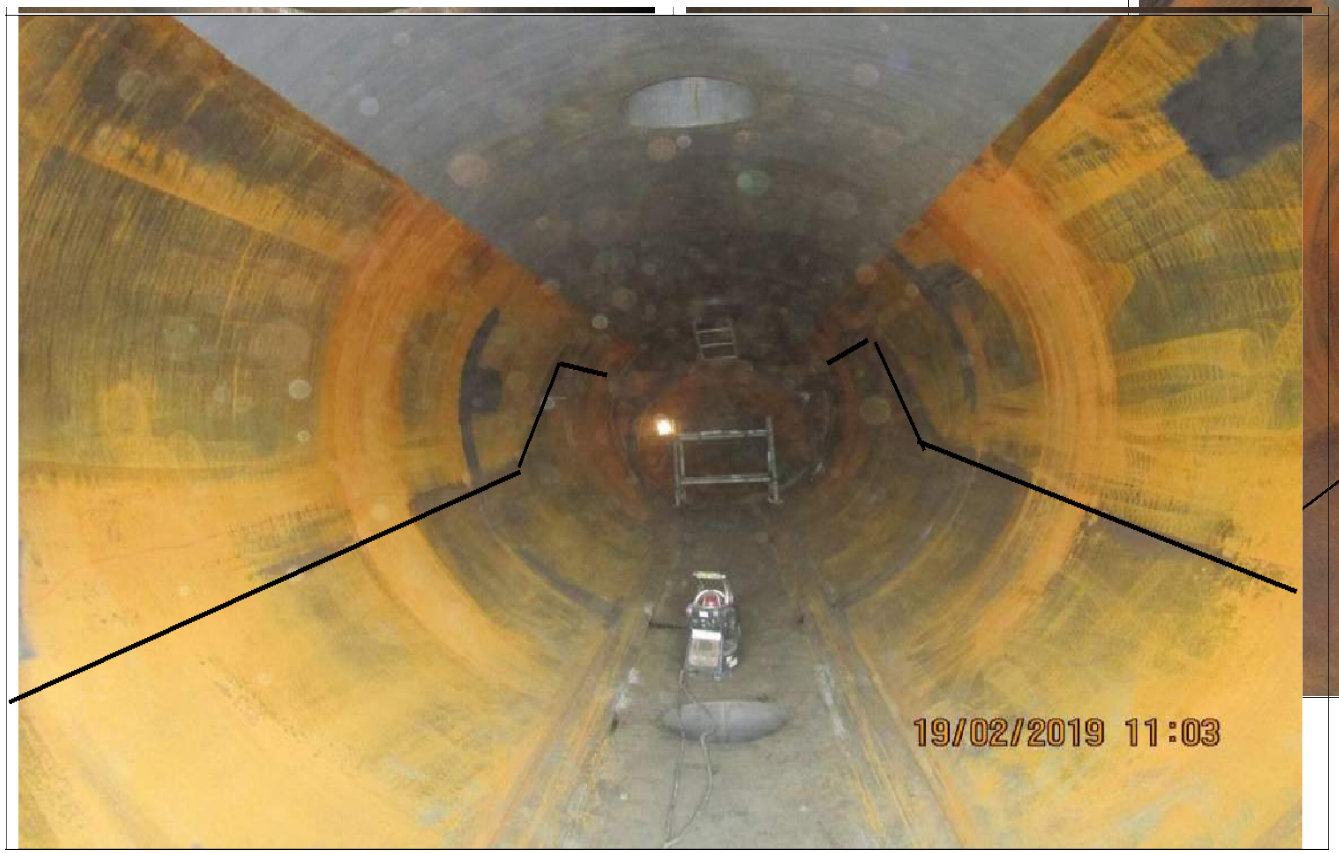
Glycol Surge Drums

AFTER

Vessels were corroded beyond corrosion allowance but were critical for operation until new vessels could be manufactured. DuraPol UHT coating stopped corrosion and allowed continued operation. Coated vessels in service since June 2014.

Case Study 5

AGR Stripper Reboilers 2 No. DuraPol UHT applied on roof section. Operating conditions of 128°C in LP Steam, MDEA amine and sour gas service.



RESULTS: Coating in excellent condition during inspection after 1 year

Conclusions & Recommendation

Tests and real life service experiences show that Specialised Coating provides excellent resistance to corrosion in amine and sour service. In fact test conditions are much more severe than those found in typical Amine Treating Units.

Specialised Coating offers following benefits:

- Full protection to equipment built from carbon steel. Alternative is to use specialist alloys or stainless-steels making projects economically unviable.
- Specialised coating is inert to amines and acid gases. Prevents metal ions going into solution reducing formation of HSS. Maintain efficiency of amine for continuous optimal use.
- Complete corrosion prevention in all areas of sour gas treating plant including absorbers, strippers, reboilers, pumps, flash drums, storage tanks, reflux drums and accumulator vessels.

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