Top of The Line Corrosion Behavior in Highly Sour Environments

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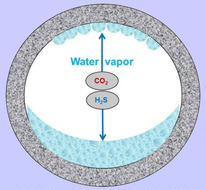
Introduction



Top of the line corrosion (TLC) mainly occurs when a significant temperature difference exists between the environment and the fluid inside the pipeline. This leads to water condensation on the inside wall of the pipeline [1].

Unlike for sour (H_2S) TLC, parameters involved in sweet (CO_2) TLC are well defined, namely water condensation rate, gas temperature, gas flow rate, CO_2 partial pressure and organic acid concentration [2]. However, the mechanisms of sour TLC, and sour corrosion for that matter, are not well understood. Only a limited amount of work has thus far been published, especially in high pressure H_2S environments. Consequently, little is known about the controlling parameters for TLC in sour environments.

Hypothesis & Objectives

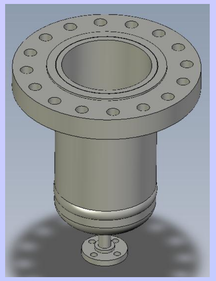
Gas and steel temperature are the main parameters which control sour top of the line corrosion through formation of more stable and protective FeS layer/polymorphs at high temperature, while water condensation rate (WCR) is the second factor where higher WCR would lower down the steel temperature and increase the TLC rate.

a) Investigate the effect of gas/steel temperature in sour TLC.
b) Study the effect of water condensation rate in sour TLC.
c) Characterize the formation of various iron sulfide polymorphs on the metal surface

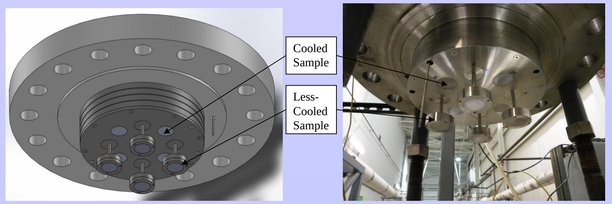
Test Matrix

Investigating	Temperature/water condensation rate			
Test material	API 5L X-65 carbon steel			
Total pressure (bar)	28			
Gas temperature (°C)	25	40	60	80
Condensation rate (mL/m²/s)	0.01	0.01&0.04	0.02&0.21	0.02&0.51
H_2S partial pressure (bar)	2			
CO_2 partial pressure (bar)	10			
Test duration	21 days			
Corrosion test measurement	Weight loss			

Experimental Setup

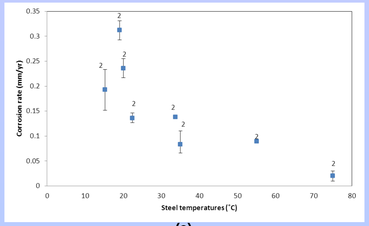


20L UNS N10276 Autoclave

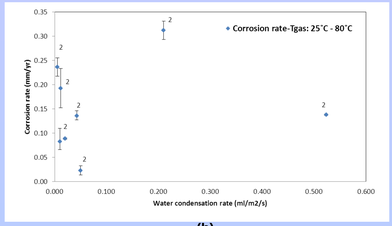


Coupons holder setup for top of line samples

Results: General Corrosion Rate, Cross Section, SEM and XRD

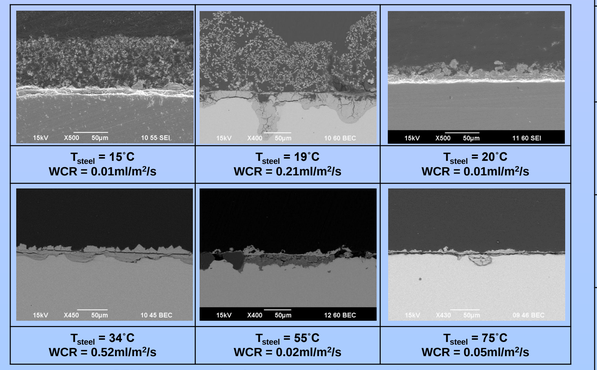


(a)

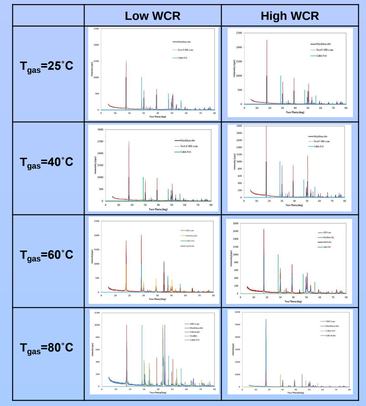


(b)

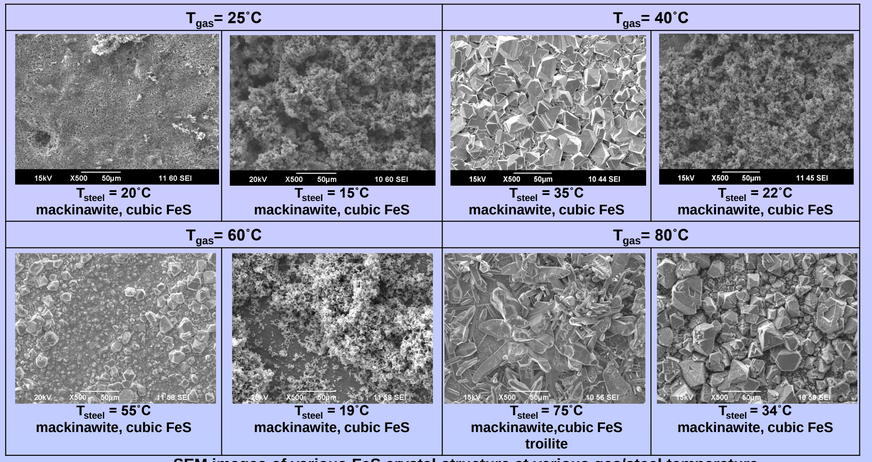
(a)TLC rate is reduced with increasing steel temperature (b) No clear relationship between water condensation rate and TLC



SEM cross-section images at various steel temperature and water condensation rate



XRD pattern for each sample at various gas temperature



SEM images of various FeS crystal structure at various gas/steel temperature

Conclusions

- The general top of the line corrosion rate decreased with increasing gas/steel temperature.
- Higher gas and steel temperature led to the formation of more protective and denser FeS layer.
- Mackinawite and cubic FeS were identified as corrosion product layer at the top of the line in most of the conditions tested while troilite was observed at higher temperature (gas temperature of 80°C and steel temperature of 75˚C).
- The water condensation rate did not have a strong effect on the corrosion rate.
- A very dense and thin layer was always present on the metal surface. In some conditions, (low temperature, high water condensation rate), a second larger and more porous outer layer was also observed.

References

1. M. Singer, A. Camacho, B. Brown and S. Nesic, "Sour Top of Line Corrosion in The Presence of Acetic Acid," in *Corrosion/10*, Houston, TX, 2010,paper 10100.
2. M. Singer, S. Nesic, D. Hinkson, Z. Zhang and H. Wang, "CO_2 Top of the Line Corrosion in Presence of Acetic Acid-A Parametric Study," in *Corrosion/09*, Atlanta, GA, 2009,paper 09292.
3. D. Pugh, S. Asher, J. Cai and W. Sisak, "Top Of Line Corrosion Mechanism for Sour Wet Gas Pipelines," in *Corrosion/09*, Houston,TX, 2009,paper 09285.

Acknowledgements

- Advisor : Professor Srdjan Nesic & Dr David Young
- Project leader : Marc Singer
- BP, ConocoPhilips, Total, ENI, Chevron, OXY, Saudi Aramco and PTTEP
- Ministry of Higher Education Malaysia and Universiti Teknologi MARA Malaysia