

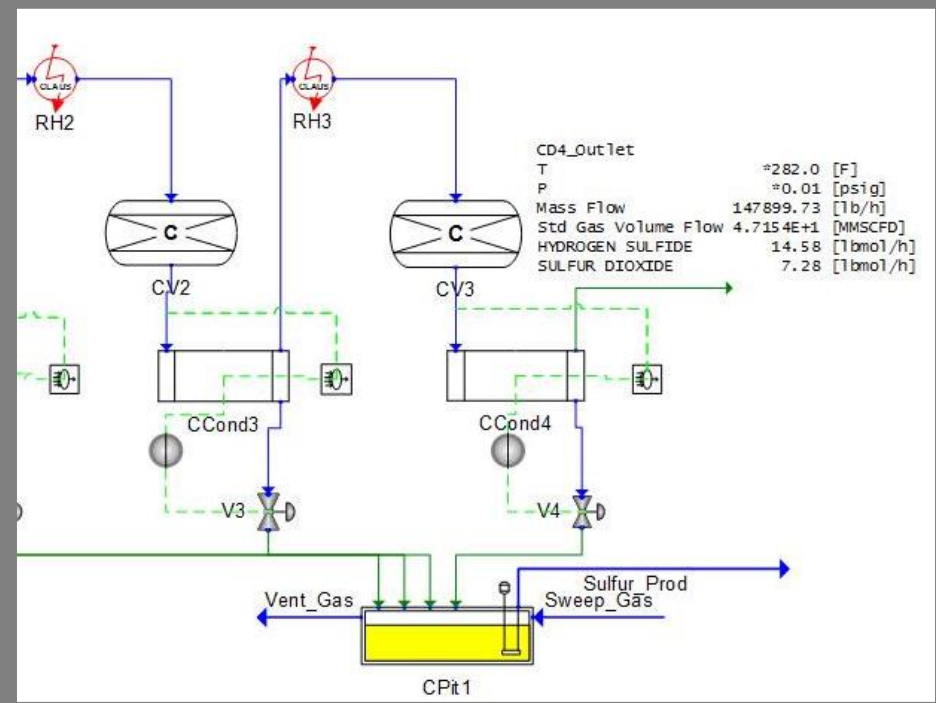


Amine Corrosion Troubleshooting with Acid Gas Enrichment Units

Virtual Vail | Thursday, September 17, 2020

At a Glance

1. Summary
2. Facility history
3. Troubleshooting
4. Next steps



Summary

The conclusion first

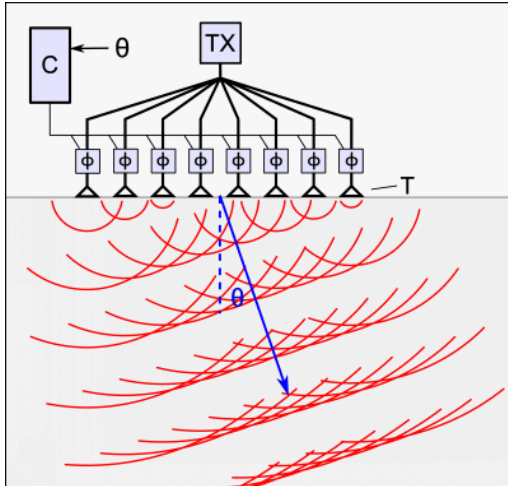


- SRE brought in to troubleshoot “accelerated corrosion” within Acid Gas Enrichment Unit Regenerator column
 - Found localized cracking at circumferential welds
 - Number of cracks identified via Phased Array Ultrasonic Testing (PAUT) increased in a short time frame

Phased Array Ultrasonic Testing

Source:

https://en.wikipedia.org/wiki/Phased_array_ultrasonics



Monolithic probes emit beam in a fixed direction

- Need to physically move to sweep beam through area

Phased array probe have multiple small elements

- Pulsed individually
- Look at range of refracted angles or various depths

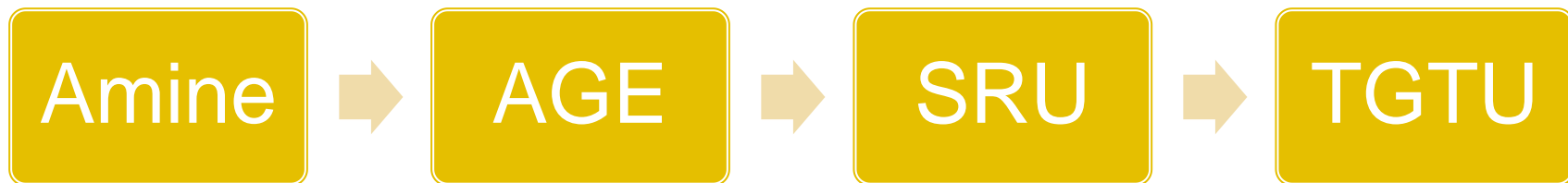
- While conducting the onsite work, SRE investigated
 - Obtained gas and liquid samples
 - Acid condensation
 - Lean amine concentration and loading
 - PAUT & hardness test results
- Enough evidence to support that vessel integrity may have been compromised

Facility History

How did we get here?



- Gas plant processing approx. 700 MMSCFD
- Raw gas 73 mol% C₁, 14.3 mol% CO₂, 1.1 mol% H₂S
- 3 identical trains (1, 2, & 3)
- Each SRU 150 TPD



Facility history



- Commissioning circa 2005
- Conducted turnarounds on all 3 trains, rotating basis
- Inspections followed standard practices
 - Cleaning of vessel
 - Visual inspection

Facility history (cont'd)



- 2015: Train 2 Regen visual inspection negative
- Dec 2018: Train 3 Regen visual inspection negative
- May 2019: Train 2 Regen visual inspection, cracks apparent, PAUT scan completed
- Oct 2019: Train 3 Regen visual inspection, cracks apparent
- Nov 2019: Train 2 Regen PAUT scan again, more cracks

Facility history (cont'd)



- Large jump in number of cracks
- Need to determine cause
- Brought in SRE

*Did not send boat samples of crack
for metallographic examination*

Aside: proper test period planning



Things to remember in coordinating consulting company to conduct investigation:

1. Provide the appropriate data
2. Ensure availability of stakeholders
3. Ask for help early

Summary of test period



Day	Description
1	Mobilization, kick-off meeting, setup GC in lab
2	Testing Train 1, review initial results; request for more documents
3	Testing Train 3, review results; request for additional documents
4	Testing other units; review of new documents received
5	Wrap-up meeting; demobilization

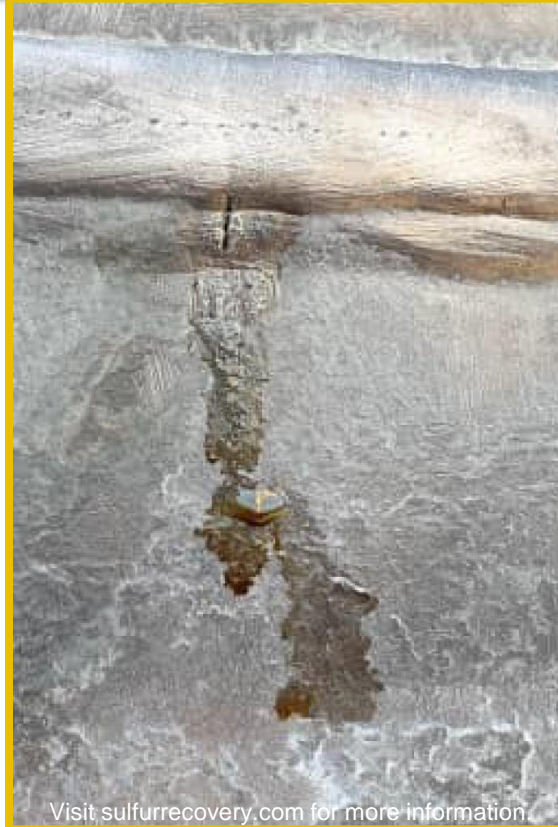
Cracking



Cracking (cont'd)



Leaking



Troubleshooting

What did SRE investigate



“Accelerated” Corrosion



- Between 2015 and 2109, inspection completed on all 3 AGE Regens
- Inspections followed routine procedures for vessels of this type
 - Visual inspection
 - NDT
- Not sufficient to identify underlying issues

“Accelerated” Corrosion (cont’d)



- Limited historic amine analysis: no short-term changes in composition
 - Recommend: quarterly detailed analysis with metals testing

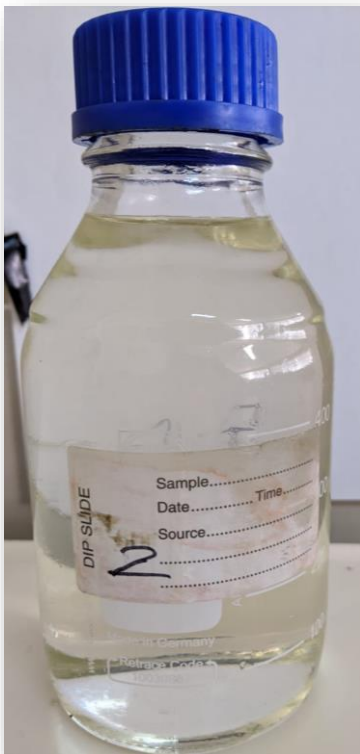
No indications that the event was an accelerated event which occurred between May and Nov 2019

Acid Condensation

- Vertical lines within the metal above weld
- Acid condensation cause by operation below dew point
- Temperature of AGE Regen was higher than typical regen conditions
- $\text{H}_2\text{S}:\text{CO}_2$ within acceptable range for FeS passivation

Acid condensation not a likely cause for failure of column

Lean amine concentration



Client requested investigation of low MDEA concentrations in high CO₂ applications



Rich loading found to be above 90% of equilibrium



Two phase flow was checked at outlet of reboiler valve and found to be 0.217% vapor

Acceptable for low corrosion

Lean amine concentration (cont'd)



- NACE Task group T-8-14 found no correlation of cracking in amine unit with amine strength
 - Majority of cracking in MEA units

No indications that the event was due to the lean amine concentration

- Client had a low H_2S loading, typically <100 ppmw
 - Can lead to loss of FeS passivation in lean section
- NACE Task group T-8-14 found that there was no correlation of cracking with amine loading
 - But rapid changes in repassivation of metal may contribute to stress corrosion cracking (SCC)

**No indications of rapid changes in loading,
therefore lean loading not a contributing factor**

- Evaluation of cracks was conducted to determine the angle
- Found 12% of the indications to be buried cracks
- Further crack type was determined to be chevron cracks and transverse cracks
 - Fabrication defect resulting from hydrogen that is produced in the weld by moisture of insufficiently dried welding materials.

- Data book given to client contained
 - Adequate procedures required for heat treating
 - Procedure to conduct UT scan post heat treatment
 - Tables to log the temperature, hold times, and UT results
- No data was provided to prove that the procedure was followed or that the UT scan was completed

Conclusion



- No process conditions found with potential to cause the cracking observed
- No proof that vessel followed PWHT and subsequent UT scan for welding verification
- Cracks found were conducive of poor welding technique

Next steps



Recommendations



- Regenerator columns need to be replaced
- Should not be done “in kind”
- Problem may be pandemic?
 - SRE found that 15 vessels at this site were handled by the same vendor

Thank You.



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