



Caerus

Corrosion Review

28-7 E280U Flowline Failure Analysis

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Introduction

The following is a review of the observations made from a 4 ½ inch flowline sample obtained from the 28-7 E28OU SWD

The well injects approximately 3,000 BWPD at approximately 700 psi.

The disposal is being treated with an iron sulfide dispersant and scale inhibitor.

A more in depth review can be given as information becomes available such as: water chemistry, bacteria monitoring, equipment run life and operating temperature.

The sample was split in half for corrosion identification

Sample Exterior, Before Cleaning

- Samples arrived wrapped in electric tape. Picture is as received.
- A hole is visible with an oily ring around it.
- Corrosion is internal to external

Hole in flowline



Sample Interior, Before Cleaning

- Oxidation and oil deposits visible.
- Solids tested positive for calcium carbonate and iron sulfide
- Iron sulfide is a common byproduct of SRB/H₂S corrosion

Hole in Tubing



Samples were cleaned to discover the cause of failure

Sample Interior, After Cleaning

- Light pitting found throughout the sample
- Isolated pits found on both sides of pipe
- Orientation of pitting suggests that the line is always wet



Pit Morphology

- Mild corrosion pitting found throughout the sample
- Iron sulfide in base of light pits suggests H_2S corrosion
- Corrosion pitting visible on either side of the welds



Pit Morphology – Bottom of Line

- Deep, isolated pits found among lighter pitting
- Pits have stair stepped pattern and pits within pits
- Characteristic of sulfate-reducing bacteria



Pit Morphology – Top of Line

- Deep, isolated pits found among lighter pitting with through hole wall
- Pit similar to bottom of line with stair stepped pattern
- Black material tested positive for iron sulfide



Pit Morphology - Additional Pictures



Conclusions

- Corrosion in flowline is exclusively internal corrosion
- Hole in tubing found in the top of the line.
- Less severe pitting found throughout the line.
- Severe, isolated pits found were on both sides of line.
- Pit morphology is stair stepped with pits within pits and iron sulfide at the base of the pits.
- Light pitting is highly characteristic of H_2S pitting.
- Severe pitting is highly characteristic of sulfate-reducing bacteria.
- Sulfate reducing bacteria secrete H_2S , which reacts with iron to form iron sulfide.
- Pitting failure likely due to Microbially Influenced Corrosion (MIC). H_2S pitting is likely a byproduct of SRB metabolism.

Recommendation

- **Perform bug bottle testing to confirm the presence of bacteria.**
- **Perform H₂S testing to confirm the presence of H₂S gas.**
- **Initiate treatment with biocide at the saltwater disposal. Treat with XC102w an initial treatment concentration of at least 100 ppm. Treatments can be applied continuously or batch as practical and economic considerations dictate.**
- **Monitor biocide performance with bug bottle testing. A typical KPI for bacteria testing is less than or equal to 2 bug bottle turns (representing 100 bacteria/mL or less)**