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Acid Corrosion Mitigation

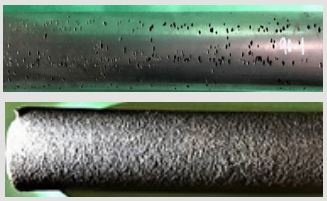
Stimulation acidizing through coiled tubing is a popular method in the oil and gas industry to improve the productivity of oil and gas wells. The process entails injecting acid fluid into the formation in order to dissolve and eliminate any substances that might be obstructing the flow of gas or oil.

However, extended exposure to these environments with inadequate corrosion protection can dissolve the coiled tubing, increase the risk of equipment failure, and cause environmental and safety hazards.

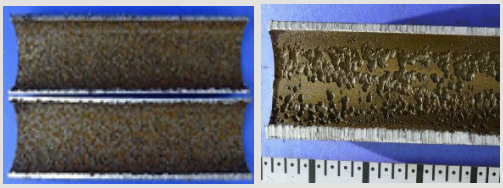
Signs of Acid Corrosion

The following images are examples of the damage in the inner and outer surface of the coiled tubing.

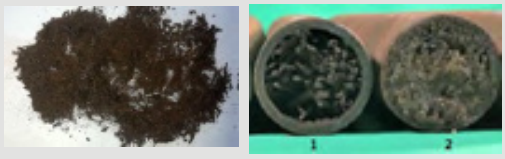
Outer surface (OD) of the CT exposed to uninhibited acid showing severe cavernous pitting and overall wall loss.



Inner surface (ID) of the CT showing heavy corrosion pitting due to acid exposure.

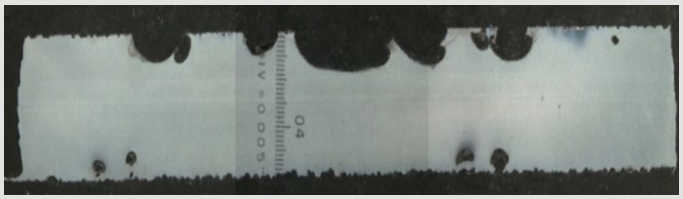


Exposure to acidic environments will cause the longitudinal weld seam and internal surface to degrade and produce scale causing plugging and BHA issues.



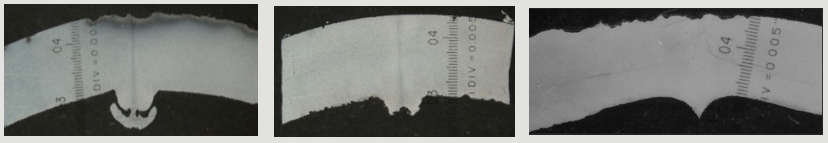
Fracture region coincident with extensive OD and ID corrosion pitting.

Metallography shows deep corrosion pitting in the base material 5-30% of nominal wall on both OD and ID.



Metallography of brand-new tubing.

Metallography of field tubing showing dissolution of the longitudinal weld seam and heavy corrosion on the outside and inside surfaces.



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Acid Corrosion Mitigation

Recommended Mitigation Practices

Reducing the corrosion pitting, wall loss, and weld seam dissolution depends on both the operational parameters, and the final neutralization process to optimize performance. Careful attention to both of these will reduce the likelihood of wall loss which causes a reduction in fatigue and increases susceptibility to field operations failures.

BEST PRACTICES DURING OPERATIONS

- Confirm that well profile and conditions are fully accounted for. Mandate pre-job testing for non-inhibited acid in the event a delay in operations occurs. Test assessments should include mass loss and pitting assessment for the entire duration of the job.
- Evaluate job tables from previous operations performed in same well to ensure all other chemicals are accounted for and potential presence of residual hazardous chemicals downhole are included and addressed in the pre-job planning.
- Examine the efficacy curves for the acid inhibitor systems to optimize it for downhole temperatures and duration. Anticipate and plan for spent acid problems which may occur during operations.
- Schedule regular, proper chemical system mixing to prevent stratification/demulsification of the inhibitor and acid. Use regular testing and verification to confirm the homogeneity and integrity of the acid and inhibitor system.

BEST PRACTICES AFTER OPERATIONS

- The post-job neutralization process is extremely important to protect the CT and equipment.
- Pump sufficient neutralizing agents with appropriately sized pigs and brush systems along with clean water. Then follow with high velocity nitrogen (N_2). Note that N_2 alone will leave 2 to 3 bbls of fluid inside the tube.
- The table below provides the recommended soda ash solution after an acid treatment. The table identifies the volume and loading of soda ash to be pumped depending on the CT string volume.
- Adjustments should be made to the pump rate to enable a 10 minute contact time.

RECOMMENDED NEUTRALIZATION FOR POST-JOB HCl ACID STIMULATION

CT Volume Range		Recommended Fresh Water		Recommended Soda Ash		Flow Rate		Pump Time Range
Barrel	m^3	Barrel	m^3	ID	kg	BPM	m^3/min	Minutes
0 — 20	0 — 3	5	1	150	68	0.5	0.079	0 — 40
20 — 60	3 — 10	10	2	200	91	1.0	0.159	20 — 60
60 — 100	10 — 16	10	2	300	136	1.0	0.159	60 — 100
100 — 140	16 — 22	20	3	400	181	2.0	0.318	50 — 70

The table recommended pill volumes, flow rates and pumping times follow the conditions below:

1. If the CT string OD is between 1.25 and 1.5 inches and the length is below 15,000 feet, the pill volume would be 5 barrels.
2. If the CT string OD is between 1.25 and 1.5 inches and the length is above 15,000 feet, the pill volume would be 10 barrels.
3. If the CT string OD is between 1.75 and 2 inches, the pill volume would be 10 barrels.
4. If the CT string OD is between 2.375 and 2.875 inches and the length is below 15,000 feet, the pill volume would be 10 barrels.
5. If the CT string OD is between 2.375 and 2.875 inches and the length is above 15,000 feet, the pill volume would be 20 barrels.
6. The pump rate and pump time was calculated to allow 10 minute contact time.

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