DURACOIL
SOUR TESTING

COILED TUBING

By FET | Global Tubing

DURACOIL IN SOUR ENVIRONMENTS

To understand the effect of H2S on quenched and tempered CT pipes, Global Tubing DURACOIL 110 grade was tested in sour environment

The effect of H2S on CT Pipes - Sulfide Stress Cracking

Sulfide stress cracking (SSC) is a form of cathodic cracking thru hydrogen embrittlement. Susceptible alloys, especially steels, react with hydrogen sulfide (H2S), forming metal sulfides (MeS) and atomic hydrogen (H+) as corrosion byproducts. SSC occurs when atomic hydrogen diffuses into the metal but remains in solution in the crystal lattice. This reduces the ductility and formability of the metal, which is termed hydrogen embrittlement. Several factors influence SSC: steel composition, heat treatments, microstructure, mechanical properties, pH, H2S partial pressure, load applied, temperature, and time. High yield strength steels (ultimate tensile above 101,526 psi or 700 MPa) are more susceptible to SSC, since their microstructure is particularly sensitive to the effects of hydrogen.

Understanding Partial Pressure

Partial pressure of a gas is the pressure exerted by one among the mixture of gases that occupies the same volume. Partial pressure for H2S is the product of total pressure by the fraction of H2S present. For example, if the pressure is 10,000 psi at 8 ppm H2S concentration, the partial pressure is 0.08 psi. The partial pressure of H2S is used to set production environment limits for carbon steels, low alloy steels, and corrosion resistant alloys. The NACE standards relate to an H2S partial pressure of 0.05 pounds per square inch absolute (psia). Steel used in these environments without inhibition and below 22HRC should be resistant below 0.05psi (0.3kPa), but since these codes are designed for static environments, coiled tubing operations should always use inhibition when sour environments are present.

As a way of illustration, the Ghawar field in Saudi Arabia (the biggest conventional oil field in the world), produces up to 40 mole % H2S. However, CT interventions are usually restricted to 10mole % H2S, with surface pressures averaging 3,000 psi in some areas, this equates to 300psi (20.7 bar) of H2S partial pressure.

Overview of DURACOIL 110 Testing in H2S Environment

Our testing procedure followed Method A of NACE TM 0177 testing procedure (with no uni-axial tensile):

- 2-3/8” OD & 0.204” WT pipe samples.
- Ends capped to isolate pipe internals from outside environment (simulating downhole environment)
- One-third of the samples inhibited with Product A, another third inhibited with Product B and the remaining samples not inhibited.
- Samples were immersed in Solution A (pH 2.7) inside a pressurized chamber with200 psi (13.8 bar) H2S partial pressure, 155psi (10.7 bar)CO2, and a total pressure of 5000psi. (345 bar) at 25C.
- Samples were tested for 96 hours ~ 4 days.
- Upon completion of the immersion test under pressure, samples were fatigue tested to failure to examine reduction in fatigue life, with and without inhibitors at 1,500 and 9,000 psi fatigue test pressure.

Why our testing methodology is more stringent

In light of the industry needs in the Middle East we conducted lab testing using the most stringent criteria allowable in a lab environment.

- Testing procedure utilized NACE Solution A with a pH of 2.7 followed by bending fatigue to examine CT performance.
- Higher Partial Pressures used than previously done by other manufacturers for full tube immersion followed by fatigue testing.
- CO2 was used to accelerate corrosion reaction thru oxygen content.
- Fatigue testing done at higher absolute “pumping pressures” than previously done.
- Ratio of sour fluid to exposed tube surface area was maximized by isolating extremities of the samples tested.

Testing Conclusions

Fatigue testing with inhibitors showed retention of fatigue life after 96 hours exposure. Both high and low pressure fatigue showed consistent fatigue results:

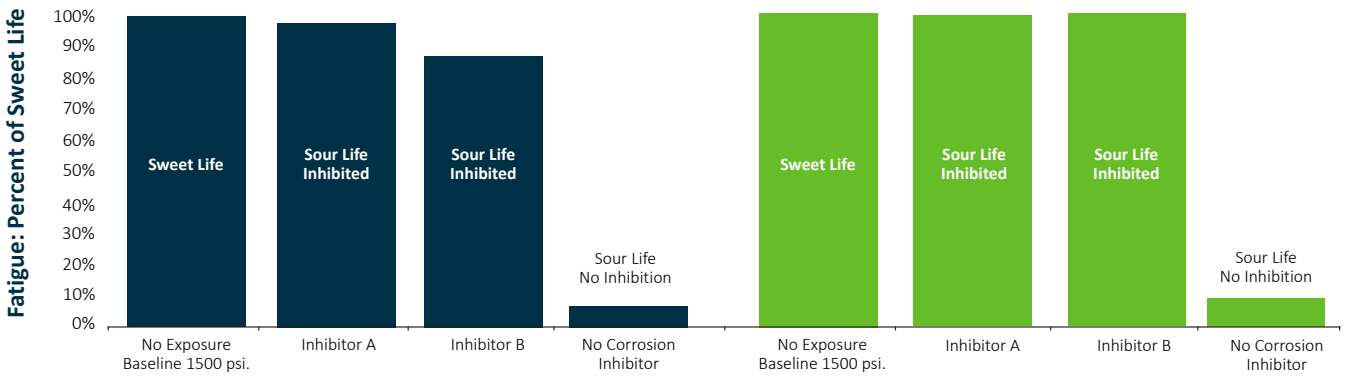
- High reduction in fatigue life without inhibition
- Fatigue life remains with the use of inhibition

Testing Comparison
Between Manufactures

HIGH STRENGTH COILED TUBING PIPES SHOULD ALWAYS BE INHIBITED IN SOUR ENVIRONMENTS

SPE Paper	SPE-218327	SPE-212878-MS	SPE-184796-MS
Company	**Global Tubing**	**Manufacturer A**	**Manufacturer B**
Failure Mode Testied	SSC/HIC	SSC/HIC	SSC/HIC
NACE Methodology	Solution A OD Tube Immersion/Fatigue	TM0177 Method C	Solution A OD Tube Immersion/Fatigue
Material Grade	110	140	95
Material Hardness	33 HRC	<=39 HRC	20 to 26 HRC
Solutions pH	2.7 (Solution A)	2.8 (Solution B)	2.7 (Solution A)
Partial Pressure H2S	13.8 bar / 200psi	71 bar /1,035 psi	1 bar/14.7 psi.
Total Test Pressure	5,000 psi	4,500 psi	14.7 psi
Exposure Time	4 days	30 days	4 days
Temperature	Ambient	Ambient	Ambient
Number of Environments Tested	1 environment with 2 inhibitors	1 environment with inhibitor	1 environment- no inhibition
	1 environment- no inhibition	1 environment- no inhibition	
Post Testing Fatigue Analysis	Yes	n/a	Yes
Post Testing Fatigue Pressures	Low pressure @ 1,500 psi High Pressure @ 9,000 psi	n/a	Not Published
Inhibitor Used	Petroleum Distillate	Yes, unpublished	None
Inhibitor concentration	Thin layer simulating lubricator	0.2% weight percent	None
Coupons Samples Age	Newly Milled Pipe	Newly Milled Pipe and fatigued (72 bending radius)	Newly Milled Pipe
Coupons Samples Source	Base material and seam	Base, bias and seam	Base material and seam
Number of Coupons per environment tested	4	12 (2 for each type of test)	Not Published
Total number of coupons tested	20	24	Not Published
Coupon wall thickness	0.204”	Not Published	Not Published
Results	Nearly 100% of fatigue life remains even after sour immersion with inhibition. Without inhibition, hydrogen cracking is observed and fatigue life is reduced compared to non-sour life.	When testing with inhibition, C Rings Pass with no cracking. Without Inhibition, hydrogen cracking is observed in all coupons.	Sour fatigue test results, performed without any inhibition, indicate that sour fatigue life is reduced by about 50% for lower CT circulating pressures and by about 30% for high circulating pressures relative to its’ non-sour life.

DC-110 Percent of Sweet Life after Sour Exposure



Low Pressure Fatigue = 1500 psi

High Pressure Fatigue = 900 psi

COILED TUBING

By FET | Global Tubing

CONTACT US TODAY

UNITED STATES

Corporate Headquarters

ADDRESS 501 County Rd. 493
P.O. Drawer 2139
Dayton, TX 77535-2139

TOLL FREE 866.891.1142
OFFICE 713.265.5000
FAX 713.265.5099

Permian Basin Service Center

ADDRESS 3707 South County Road 116
Midland, TX 79706

TOLL FREE 866.891.1142
FAX 713.265.5099

Northeast Service Center

ADDRESS 1040 Franklin Drive
Smock, PA 15480

TOLL FREE 866.891.1142
FAX 713.265.5099

CANADA

Red Deer Service Center

ADDRESS 7754 47 Avenue Close
Red Deer, AB T4P 2J9

OFFICE 403.346.9231
MOBILE 403.771.4076
FAX 403.346.9254

Northwest Service Center

ADDRESS 9101 – 150 Avenue
Grande Prairie, AB T8X 0B1

OFFICE 403.346.9231
MOBILE 403.771.4076
FAX 403.346.9254

MIDDLE EAST

Forum Arabia

ADDRESS 2nd Industrial City, Dammam 34325
Eastern Province, Kingdom of Saudi Arabia

CT SALES +2 0100.077.3206

Forum Dubai

ADDRESS Oilfields Supply Center, Building 20/21,
Jebel Ali Free Zone, Dubai., UAE.

CT SALES +2 0100.077.3206

f-e-t.com/global-tubing