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NEWSLETTER

HEGGEL® Corr 240

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Advanced Coating: Hydrogen Corrosion At Elevated Pressures

Brief on an Instance of High Pressure Services

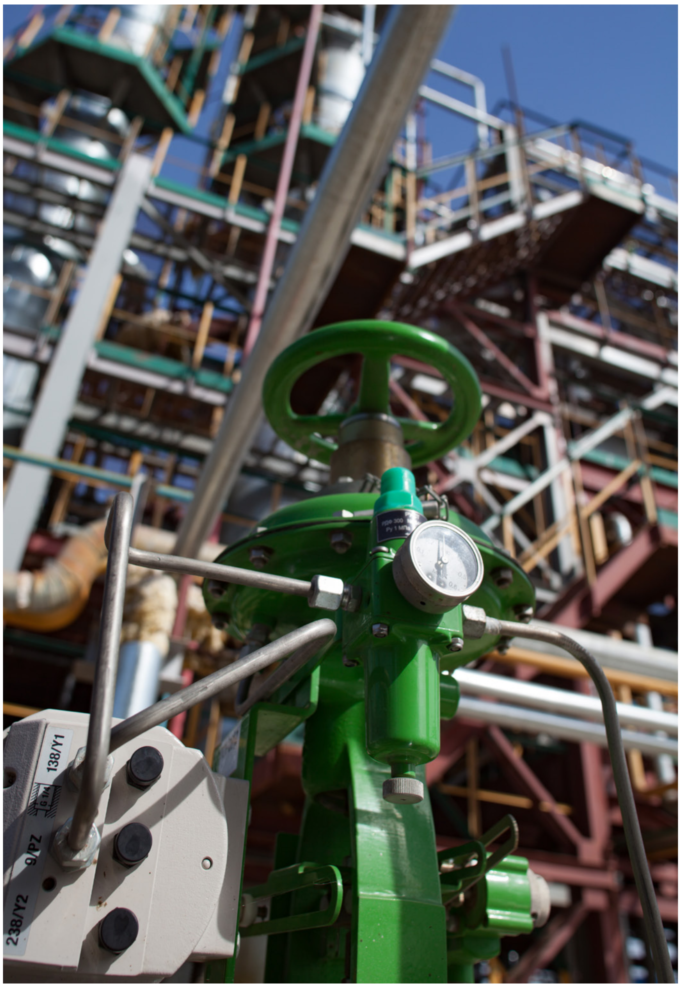
Whether in exploration or production sectors, sour services are associated with the environments in oil and gas industries where equipment is operating in hydrogen sulfide (H_2S) media.

Hydrogen sulfide (H_2S) is a corrosive, toxic and explosive compound; and sour gas is actually the natural gas containing measurable amounts of hydrogen sulfide and minimum total pressure. Moreover, the CO_2 and H_2S content of the fluids conjugated with elevated pressure and high temperature creates very corrosive circumstances, that significantly attack the metallic substrates in sour services.

Hydrogen sulfide (H_2S) acidifies water and causes pitting corrosion to carbon steel pipelines; in addition, dissolved-in-water hydrogen sulfide forms the very corrosive sulfuric acid (H_2SO_4) which is often referred to as sour corrosion, occurring in various forms of sulfide stress cracking (SSC) or hydrogen embrittlement, causing failure at stress levels below the normal yield strength of the metallic constituents.

Sour corrosion could occur in manifold systems with process conditions involving wet hydrogen sulfide through oil and gas industry due to the build-up of hydrogen sulfide on metallic surfaces; in the presence of water and hydrogen sulfide, atomic hydrogen is produced and through a cathodic reaction enters the metallic substrates, aggravating cracking mechanisms due to hydrogen embrittlement, and imposing a major risk of failure in different modes on the equipment in sour environment.

Steel substrates exposed to wet H_2S are highly susceptible to various types of Hydrogen Embrittlement (HE). Pressurization of trap sites by hydrogen causes crack initiation and propagation, resulting in early destruction of the metal due to the combined effect of both hydrogen penetration and the residual and/or applied tensile stress in wet H_2S environment.



The effects of high H_2S pressure on corrosion rates in sour gas services are less well understood, mainly due to difficult simulation of the real service conditions in laboratory to perform tests; however, high pressure H_2S exhibits superior wetting properties and a more intensive penetration through small pores. These features have a significant impact on extending damages and accelerating the corrosion rates.

Hydrogen Embrittlement (HE)

As hydrogen is inevitably generated by wet H_2S corrosion reactions of steel substrates in free-of-oxygen environments such as wet sour gas or sour crude oil services, small hydrogen atoms intensely permeate solid contact surfaces, leading to considerable loss in metal's ductility and tensile strength. Destructing the integrity of metal substrates, the consequent mechanical damages by absorbed hydrogen is called Hydrogen embrittlement (HE).

The material's susceptibility to embrittlement is to a great extent dependent on the amount of absorbed hydrogen and the microstructure of the material itself; however, temperature is an effective variable value that can influence the severity of hydrogen embrittlement.

In case the residual and/or applied stress imposed on a hydrogen-embrittled material reaches a sufficient degree, embrittlement becomes significant and leads to cracking.
There are several terms describing the cracking phenomenon associated with hydrogen embrittlement; however, four types of cracking frequently emerge in sour environments:

- ✓ Hydrogen-induced Cracking (HIC) or Hydrogen Pressure-induced Cracking (HPIC)
- ✓ Stress corrosion cracking (SCC)
- ✓ Sulphide stress cracking (SSC)
- ✓ Stress-oriented hydrogen-induced cracking (SOHIC)

Introduction and diffusion of hydrogen into the metals and alloys, and the subsequent embrittlement and cracking phenomena, severely decrease the fracture strength of the structures involved in sour services, and activate the creation and/or propagation mechanisms of surface/internal defects, and corrosion degradation processes.

Residual stress of substrate's materials due to plastic deformations during the manufacturing process of the equipment is a factor that coupled with the permeation of hydrogen in wet H_2S environment can lead to cracking and brittle failures.

Several industrial units are particularly exposed to destructive damages by wet H_2S; the life-time of metal structures like pipelines is notably reduced due to nucleation and progressive growth of hydrogen cracks, and the deteriorating effects of hydrogen corrosion in acidic environments.

Solutions

Given the possibility of sudden failure due to progression of severe deterioration mechanisms by wet H_2S, it is very important to pay special attention to high-risk areas and equipment.

Although frequent monitoring by NDT methods, Ultrasonic tests, etc. is reliable for detecting cracks and categorizing damages, these approaches cannot eliminate the chance of corrosion in critical infrastructures.

Material selection is also one of the preliminary steps to effectively control the rate of corrosion; however, hydrogen sulfide H_2S can embrittle even high-hardness, high-strength carbon steels, as well as most martensitic stainless steels.

Chemical inhibitors could also be a difficult choice for corrosion prevention in sour services, due to the adverse mutual effects of inhibitors with different formulations.

To achieve a most durable performance of corrosion protection in service conditions with multiple variables, coating is a clever solution to maintain the integrity of assets and safely protect the structures against corrosion related failures.

HEGGEL Corr 240 is an advanced coating offering anti-corrosion properties, with a proven protective performance at elevated pressures and high temperatures.

Also, due to its resistance against gas permeation, **HEGGEL Corr 240** is an applicable choice for equipment in sour services to prevent hydrogen corrosion.

HEGGEL® Corr 240

Super Pressure Modified Phenol Resin

HEGGEL Corr 240 is a rapid curing advanced coating demonstrating high performance in corrosion protection against service environments with various harsh conditions.

With high abrasion resistance and a smooth, matt surface finish, **HEGGEL Corr 240** increases the flow efficiency and prevents build-up of chemicals and scales including paraffin, asphaltene, etc. **HEGGEL Corr 240** has an extremely high adhesive strength in excess of 4200 psi, coupled with resistance to gas permeation, to withstand explosive decompression cycles, as well as hydrogen corrosion from high pressure sour gas services which makes metal substrates brittle.

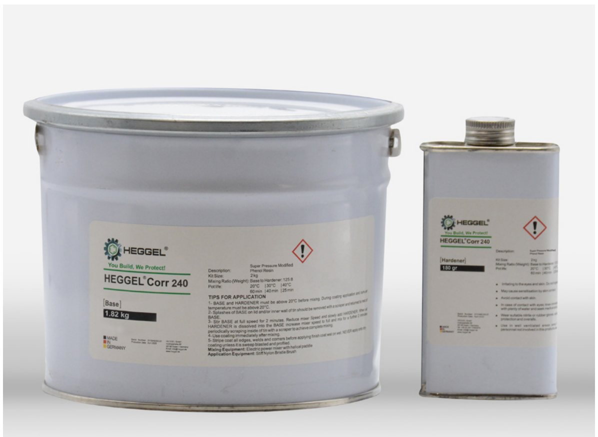
HEGGEL Corr 240 is a modified phenolic epoxy resistant to elevated temperatures up to 180°C dry heat and 150°C under gaseous immersed conditions.

Characteristics

- Self-priming
- Solvent free
- Single coat application
- Tenacious bonding to metallic surfaces
- Excellent resistance against exposures to high-pressure process fluids and gas mixtures
- Specifically designed for gas pressure/separator vessels and down-hole tubular
- Excellent resistance to hydrocarbons, water and gases rich in H_2S and CO_2
- Chemical resistance to acids and solvents
- High abrasion and impact resistance
- Resistance to explosive decompression

Application Areas

- Internals of valves and pipework
- Internals of pressure / separator vessels
- Production tubing, seawater and gas injection lines
- Flow lines and down hole equipment



Typical Chemical Resistance

- Sulfuric acid 90%
- Hydrochloric acid 37%
- Glacial acetic 50%
- Phosphoric acid 84%
- Nitric acid 30%
- Sodium hypochlorite 15%
- MEK, Toluene, Xylene, Acetone, Ammonia
- Sweet and sour crude oil
- Gas rich in H_2S, CO_2 and water vapor
- Any chemical solution rich in chlorides or sulphates

Technical Data	
Abrasion Resistance ASTM D4060	12 mg weight loss Taber CS-17/1kg/1000 cycles
Adhesive Strength ASTM D4541	310 kg/cm^2 (cohesive failure)
Autoclave Test NACE TM 0185	Temperature: 266 °F Pressure: 7500 psi Fluids: Sour Crude / Acidified Seawater (50% / 50%) Gas: Methane / CO_2 (85% / 15%) Decompression Rate: 625 psi per minute Result: Pass with no delamination / blisters
Impact Resistance ASTM G14	Forward: 10 Joules Reverse: 3 Joules
Temperature Resistance NACE TM0174	150°C Immersed 180°C Non-Immersed