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Model Modules to Assist Assessing and Controlling Stress Corrosion Cracking #126
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SCC is a mechanism of cracking that occurs where a tensile stress acts on a material susceptible to cracking in a corrosion environment. For pipelines the tensile stress is pressure induced. The environment comprises ground water, inorganic salts and various decaying matter that in the presence of typical levels of cathodic protection when imposed potential for corrosion control produces varying amounts of carbonic acid, and carbonate and bicarbonate ions at the surface of the interface, whereas hydrogen evolution is the cathodic reaction. Hydrogen formed is released to the atmosphere, diffused and/or accumulated inside of the metallic structure; therefore corrosion process as well as hydrogen formation provokes microstructural and surface changes of the metallic structure. Most line pipe steels have been found susceptible to cracking in such environments at sufficient stress and selected mixes of these constituents.

Hydrogen evolution reaction by means of electrode kinetics is considered one of the most important reactions in electrochemistry when a metallic structure (electrode) is in contact with an electrolyte (soil, water). There are two general steps for this reaction; the first is the transport of the species that are going to originate it. Second step is the electrochemical reaction (recombination reaction of atomic H). Once the hydrogen gas is formed at the interface, the discharge process might occur by using different paths. The first path considers the release of the $H_2(g)$ to the atmosphere or surrounded environment; second path is the diffusion and concentration inside of the microstructure. Because the characteristics of NNSCC are dominated by chemistry of the bulk solution, anodic dissolution of the metallic structure, hydrogen embrittlement, materials behavior and mechanical stress (microplasticity) is necessary to quantify H_2 that affects the SCC phenomenon. Total or partial hydrogen formed can be followed by electrochemical techniques. Therefore stochiometric ratio is considered for laboratory conditions, to quantify the amount of hydrogen that is formed in electrolysis at the surface of the steel electrode and/or the hydrogen that diffuses inside the metal.

Integration of the iron carbonate precipitation as the product of hydrogen and ferrous ions from iron dissolution and pH conditions, with hydrogen formation and its quantification under load conditions will describe the characteristics of the electrochemical phenomenon, and therefore microplasticity effects once stress mechanical in included in the analysis for NNSCC phenomenon. When the unification of hydrogen formation, with the electrochemistry of the metal-electrolyte interface and stress conditions are met, the phenomenological and modeling of the process will complete the model extensively.

Work thus far has focused on the mechanism for near-neutral SCC (NNSCC), by evaluating methodologies and practices to characterize hydrogen effect on the microplasticity and quantifying the stochiometric ratio of this gas formed.

We have completed the underlying literature assessment and begun to finalize a postulated electrochemical mechanism for NNSCC. We also have initiated experiments designed to establish the optimum condition for cracking kinetics via beaker studies, and quantification of hydrogen under unloaded conditions. Work will continue on both aspects over the next several months.