Quarterly Report

Date of Report: December 5, 2005

Contract Number: DTRS56005-T-0003

Prepared for: DOT RSPA

Project Title: Model Modules to Assist Assessing and Controlling Stress Corrosion Cracking #126

Prepared by: Battelle

For quarterly period ending: November 30, 2005

Activities/Deliverables Completed

	SCH Date	CMPL Date
Task #1: Mechanism for NNSCC developed	06/30/2005	**07/30/2005**
Task #2: Optimum conditions for kinetics via beaker studies developed.	06/03/2005	**06/30/2005**
Task #6: Evaluate practices to quantify hydrogen effects on microplasticity.	06/30/2005	**07/01/2005**
Task #7: Characterize effect of field-factors on NNSCC susceptibility		**12/31/2005**
Task #3 Validity of mechanism established by laboratory nucleation testing		**12/31/2005**
Task #8 Develop parametric results quantifying evolution of hydrogen		01/15/2005

- Technical Status – A key to modeling SCC on pipelines is the need to determine the kinetics of cracking, which differ for NN-pH SCC versus high-pH SCC. Thus, before elaborating models for SCC it is necessary to discriminate from field data which form of cracking is anticipated. A key focus thus far has been the ability to model the discriminating factors. Accordingly, thermodynamic predictions have been considered based on potential-pH diagrams for different temperatures that are validated with experimental data. A multiligant species diagram is used to build the conditions of NS4 solution at different temperatures and concentration of species. Thermodynamic plots and calculations are available through a computer algorithm programmed in Maple© software.

- Ionic flux modeling considers kinetic and transport phenomena equations for the electrochemical cell that simulated the steel-electrolyte for NNSCC for unload conditions. The model considers all species that appears in solution, and the interaction with the metallic structure once the iron carbonate, and CO_2 homogeneous reactions are included the model describe concentration profile at specific time of each ionic species along the layers from the bulk solution to the interface.

- Experiments for the unstressed state of line-pipe steel are still ongoing, to explore the interface for different HCO_3^-, and ionic concentrations presented in underground soil conditions (NS4 solution). Potentiostatic experiments are recorded and preformed for hydrogen diffusion coefficient and SEM analysis will give the hydrogen permeation profile.

- Study of stressed specimens is being planned. Loading conditions are being planned according to the importance of the variables determined in the unstressed state, with the stress-corrosion cracking cell is built following those characteristics.

- Business Status – Cell design for load applications will be finished and tested by the end of the month of December.

Results and Conclusions

The software to predict the thermodynamic response is finished and currently being tested by using experimental data under steady state conditions. This thermodynamic model will be used for further calculations and predictions, with the software made available for general use through this project.

The mechanistic model based on transport phenomena and kinetics is finished and started to be programmed for prediction and parametric analysis. This model will be validated by means of laboratory data. The test-cell is designed and built such that the experiments on stressed specimens can begin shortly, under a range of load-controlled conditions.

Results for unstressed specimens characterize the mechanisms and the variables that influence the film formation. This film-growth considers and locates sites where active dissolution is occurring or where the layer is blocking the metal – electrolyte interaction. Stressed specimens will distinguish the mechanism and the influence of the hydrogen formed, and diffused, and film growth and dissolution.

Issues, Problems or Challenges

Mechanical loading combined with electrochemical factors is the challenge for continued modeling. Once the expression or model for hydrogen permeation and metallic dissolution under stress is obtained and validated with experimental results, we will have the basis to quantify the fundamental aspects of NN-pH SCC.

Plans for Future Activity

The experimental work will for unstressed conditions during the next couple of months. Potentiostatic experiments are schedule for the entire experimental matrix, with Electrochemical Impedance Spectroscopy used for interface conditions.

Programming the model has started and will be validated for conditions where the total hydrogen can be subtracted from the permeation hydrogen.

The experimental results from electrochemical testing combined with stressed-specimen testing will give semi-empirical relations or parametric expressions that correlate hydrogen formation with SCC conditions over a range of conditions. From this point on we will use a standard cell for NN-pH SCC testing.

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We finished a computer program coded in Maple© to calculate the predominant compounds for a Fe-CO_2-Cl--SO_4-H_2O which includes the thermodynamic calculations for different concentrations and high temperature data (more than 25 C up to 90C).

Validation of thermodynamics was performed by using experimental studies under steady stat conditions, corrosion products and different ionic concentrations and CO_2, resulting in good agreement for the feasibility of the electrochemical reaction products.

The proposed kinetic algorithm includes flux prediction of the ionic species and how they are accumulating at the interface, or react and form different compounds. Hydrogen formation at the interface is considered in this model.

Experimental set up for stressed-specimen conditions under different electrochemical conditions is addressed in the design of the cell.