EMSP #86803

Underground Corrosion after 32 Years: A Study of Fate and Transport

1. Research Objective

In 1970, the National Bureau of Standards (NBS), now call National Institute of Standards and Technology (NIST), implemented the most ambitious and comprehensive long-term corrosion behavior test to date for stainless steels in soil environments. Over 32 years have passed since scientists buried 6,324 specimens from stainless steel types, specialty alloys, composite configurations, and multiple material forms and treatment conditions at six distinctive soil-type sites throughout the country. At the start of this research project, more than 190 specimens per site, exceeding a total of 1000 specimens, remained undisturbed, a buried treasure of subsurface scientific data.

This research project advocates the completion of the NIST corrosion study along with a thorough examination of the soil and environment surrounding the specimens. The project takes an interdisciplinary research approach that will correlate the complicated interrelationships among metal integrity, corrosion rates, corrosion mechanisms, soil properties, soil microbiology, plant and animal interaction with corrosion products, and fate and transport of metallic ions. The results will provide much-needed data on corrosion rates, underground material degradation, and the behavior of corrosion products in the near-field vadose zone. The data will improve the ability to predict the fate and transport of chemical and radiological contaminants at sites throughout the DOE complex. The research scope is focused on one of the six available sites, Site D, near Wildwood, NJ.

2. Research Progress and Implications

As of June 1, 2004, the 3-year Environmental Management Science Program (EMSP) research project #86803 has been in progress for 20 months. The initial activities consisted of obtaining historical background and gathering the original test information surviving at NIST. During this past 12 months of the project, the project team, along with an undergraduate intern, collected historical climate data to compare each of the six sites. The climate data along with the historical corrosion data and site soils characterization were presented as part of a team workshop held in August 2003. Several other important aspects of each site were also presented along with retrieval scenarios and data objectives.

Although, the team agreed that Site A has the most value with regards to being an analog for several different sites around the DOE complex, Site D, near Wildwood, NJ provides the best research learning opportunity and was chosen as the target for the investigation for this research scope. Also, costs would increase for traveling and mobilization, so the team decided to limit the investigation to three of the six trenches at the site with first priority going to one of the 1970's trenches with the 200, 300, and 400 stainless steel series. This also would provide a better learning experience while still obtaining a reasonable data set for the analysis work. In all, 198 metal samples were planned for the recovery along with the associated environmental samples.

With the decision made to focus on Site D, the research focused on obtaining permission from the United States Coast Guard Loran Support Unit and planning activities for obtaining quality data from the site. The USCG LSU was extremely supportive of our efforts and assisted our team in preparing the site for the surface survey, sampling, and excavation.

The team mobilized early in April 2004 for the recovery. (See photo summary in Section 5.) Conditions at the site were extremely challenging with groundwater being within a few centimeters of the surface. The conditions slowed the progress and time was the limiting factor. The team managed to excavate one trench at the site and recovered 53 metal samples. Four of the samples were recovered with about 7 cm of native soils completely surrounding the sample (intact samples). Site D soils and soil water were also sampled for analysis of characterization properties and for microbiological investigation. A hydrology station was assembled at the site to provide active monitoring using three tensiometers, one thermocouple, and one time domain reflectometer. Data from the station will be collected for at least one year to characterized the localized hydrological conditions. Samples were carefully packaged and shipped to the analytical laboratories (contract, SRTC and INEEL). Reclamation of the trench was performed to reestablish the grade and vegetation. Analysis of the samples is expected to proceed during the next months of the project.

While the team was in the area, sites B, C and E were visited with the objective of obtaining GPS coordinates of the sites for future reference as to their locations. Remarkably the trench post markers at Site C, a phragmite-covered wetland, were located during this visit. Of the sites visited, Site D remains to be in the best overall condition and provides ample opportunity for future continued study.

3. Planned Activities

- June – September 2004 – The top priority is to analyze the soil, water, and metal samples.
- A graduate summer intern, Alecia Olson, assisting the microbiological investigation.
- FY 05 – Continue analysis work, modeling of results and final reporting.
- Publish peer reviewed results.

4. Information Access

"*Simulated Service Testing in Soil*," M. K. Adler Flitton, INEEL and E.Escalante. ASM Handbook, Volume 13A Corrosion: Fundamentals, Testing, and Protection. October 2003. Pages 497-500.

5. Optional Additional Information

As the research team, we would like to acknowledge the United States Coast Guard Loran Support Unit. Without the support of the base commander, John Macaluso and the assistance from the project's point-of-contact, Jim Fiocca, we could not have accomplished the recovery.

Special thanks to the assistance from our 2003 summer intern, physics major, William Evans from Bingham Young University.

Site D Recovery – Photo Summary

Above: Site D June 2003 conditions.

Right: Jim Fiocca (USCG LSU) and Larry Zirker, (INEEL) prepared Site D in April 2004, for coupon recovery and site sampling.

Left: One of the 1971 coupon trenches with subsidence directly over the coupon locations (April 2004).

Below: This tree stump - with 30 tree-rings – was in the center of the 1970 trench (April 2004).

Above Left: In the trench, Kay Adler Flitton (INEEL) and to the right of the trench, Kathy Marshall (SRTC), work on removing overburden, pumping groundwater, and sampling soil and ground water during coupon recovery (April 2004).

Above Right: Water table resides just below the surface of the 1970 trenches during excavation (April 2004).

Left: Carolyn Bishop (INEEL) installs the Site D hydrology station with three tensiometers, a thermocouple and a reflectometer. A solar panel will provide recharge capability for the data logger (April 2004).

Right: Kathy Marshall (SRTC) works on reclaiming the 1970 trench after sample recovery (April 2004).

Above Left: U-bend stressed corrosion samples upon recovery (April 2004).

Right: Double U-bend 301 sensitized corrosion coupon with adhering corrosion products (April 2004).

Left: Galvanic coupled sample set (April 2004).

Below Left: Close up of copper anode with attached wire (April 2004).

Below Right: Close-up of 409 stainless steel cathode at corner with attached wire (April 2004).

Above Left: 409 stainless steel pipe sample upon recovery (April 2004).
Above Right: 304 stainless steel pipe sample (April 2004).

Above Left: 304 stainless steel plate (April 2004).

Above Right: 301 stainless steel sensitized plate (April 2004).

6. Optional Proprietary Information

No proprietary information to report at this time.