INL/EXT-06-11878

Annual Report For EMSP No. 86803

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

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The INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance

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Prepared for the
U.S. Department of Energy
Office of Science Education and Technical Information
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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

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Research Objective

Improved estimates for corrosion rates in variably saturated porous media are required by the U.S. Department of Energy to maintain long-term storage of radioactive contaminants in stainless steel containers. To better define these parameters, research was undertaken to complete the National Institute of Standards and Technology's (NIST) long-term study of buried stainless steel began 35 years ago. The 1970 study was initiated by the National Bureau of Standards (NBS), now known as NIST, when over 1000 specimens—including stainless steel Types 201, 202, 301, 304, 316, 409, 410, 430, and 434—configured as plates, U-bend, and tubes in both annealed and cold worked conditions with various treatments—were buried at six distinctive soil-type sites throughout the United States. During the first eight years of the study, four of five planned removals were completed with specimens retrieved after one, two, four, and eight years at each of the six sites. The fifth and final set of specimens remained undisturbed for over 34 years.

Researchers from Department of Energy (DOE) National Laboratories at the Idaho and the Savannah River Sites recovered and are analyzing part of a final set of specimens buried at Site D, near Wildwood, NJ. Findings included estimates for 32-year corrosion rates, transport of corrosion product, and elucidation of the site's hydrogeobiochemistry. An interdisciplinary research team unraveled 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. This research provides long-term corrosion and transport data (without the 35-year test expense) that can reduce the uncertainty associated with long-term waste storage and improve fate and transport modeling predictions throughout the DOE complex. The research also provides improvements in several characterization techniques.

Research Progress and Implications

The objectives for this research are being accomplished through separate investigations in the different discipline areas that will be integrated to assess corrosion and the surrounding environmental factors. This report presents the progress of Fiscal Year 2006. Although the individual investigations have yet to be integrated and research schedule was limited due to contractual obligations of the investigators, the two areas of focus during this year's research are reported below.

Specimen Mass Loss.

The plate specimens were the primary focus of investigation. Once the adhering material had been carefully examined, documenting the specimens was accomplished. Specimens were visually examined, cleaned, weighed, measured, and photographed—all leading to mass loss determinations. NIST personnel will assist in providing a methodology to determine mass loss uncertainty. Preliminary results indicate that the sensitized specimens—Types 304 and Type 301—sustained the greatest corrosion. To a lesser degree, the 400 series (Types 409, 410, and 434) evidenced local corrosion. Rust and black staining was observed on these specimens; sandy corrosion product adhered to localized areas; and pitting was evident. Most attacks occurred in localized areas. A technical paper has been submitted for peer review and presentation at the international association of corrosion engineering in March of 2007.

Microbial Investigations. The objective of the microbiological component of this study was to demonstrate applicability of an innovative radioactive isotope method for imaging microbial activity to a comprehensive study of metal corrosion. The technique was combined with a more conventional radioactive tracer method for detecting sulfate reduction activity in soil associated with the specimens. Tests were performed on four of the stainless steel specimens and soils recovered from the Wildwood, New Jersey site. Together the techniques provide a method for evaluating low metabolic levels of activity that have the potential for significant cumulative corrosion effects. The findings have direct relevance to material storage and waste disposal throughout the nuclear industry. Results from this study show the feasibility of mapping microbial activity to substrate surfaces for evaluation of corrosion potential. Soil organisms, initially present at very low numbers, may ultimately colonize resistant materials such as stainless steels. Results will be presented in a technical paper that has been submitted for peer review and presentation at the international association of corrosion engineering in March of 2007.

Planned Activities

- Integrate individual investigations to determine environmental impacts on corrosion and corrosion impacts on the environment.
- Thirty-two year corrosion rates will be estimated for each specimen.
- Corrosion product transport rates and distances will be determined.
- Determination on the viability of specimen welds will be finished.
- Develop/calibrate numerical tool to simulate corrosion transport.
- Two papers accepted to NACE 2007.
- Two peer-reviewed papers are being written or are in progress.

Information Access

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