CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: NACE CORROSION/2003 Annual Conference and Exposition
Project No. 20.06002.01.081; AI 06002.081.310

DATE/PLACE: March 16–20, 2003
San Diego, California

AUTHORS: G.A. Cragnolino, D.S. Dunn, V. Jain, and L. Yang,

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PERSONS PRESENT: G.A. Cragnolino, D.S. Dunn, V. Jain, and L. Yang (CNWRA), and about 4000 representatives from various countries and organizations.

BACKGROUND AND PURPOSE OF TRIP:

The annual NACE International Corrosion Conference and Exposition features technical symposia, research symposia, technical committee meetings, and an exhibitor show. The main goals of attending the workshop were to:

- Present papers authored by the Center for Nuclear Waste Regulatory Analyses (CNWRA) staff that were included in a several symposia
- Chair Symposia and Technical Committee Meetings
- Review the presentations from the U.S. Department of Energy (DOE) high-level waste program and work supported by the State of Nevada
- Make contacts with prospective candidates to fill open positions within the CNWRA

In addition to presentations in the technical symposia, CNWRA staff played an active role in the organization of the several symposia and participation in technical committee meetings.

MEETING SUMMARY

Papers co-authored by the CNWRA staff and presented at the Corrosion/2003 conference are listed below:

Measurement of Corrosion in Saturated Solutions Under Salt Deposits Using Coupled Multielectrode Array by L. Yang, R. Pabalan, L. Browning and G. Cragnolino. Presented in the Corrosion Sensors Symposium.

Studies of Microbiological Influenced Corrosion Using Coupled Multielectrode Array Sensor by C.S. Brossia and L. Yang. Presented in the Microbiologically Influenced Corrosion Symposium.

An Electrochemical Approach to Predicting and Monitoring Localized Corrosion in Chemical

Process Streams, by N. Sridhar, C.S. Brossia, D.S. Dunn, L. Yang, A. Andreko, M. H. Dorsey, B. Saldanha, and S.L. Grise. Presented in the Advances in Electrochemical Techniques for Monitoring of Corrosion and Corrosion Control Symposium.

Effects of Potential and Environment on the Stress Corrosion Cracking Susceptibility of Nickel-Chromium-Molybdenum Alloys Stress by G.A. Cragnolino, D.S. Dunn, and Y.-M. Pan. Presented in the Environmentally Assisted Cracking Symposium.

Effect of Measurement Methods and Solution Chemistry on the Evaluation of Localized Corrosion of Candidate High-Level Waste Container Materials by V. Jain, D.S. Dunn, N. Sridhar, and L. Yang. Presented in the Corrosion in Nuclear Systems Symposium.

Localized Corrosion Susceptibility of Alloy 22 Comparison by D.S. Dunn, G.A. Cragnolino, L. Yang, and Y.-M. Pan. Presented in the Corrosion in Nuclear Systems Symposium.

Papers presented by the CNWRA staff were well received and prompted questions and subsequent discussion.

Narasi Sridhar received the NACE International Technical Achievements Award for his significant achievements in corrosion research and engineering.

Corrosion in Nuclear Systems

The Corrosion in Nuclear Systems Symposia featured seven papers focused on corrosion in nuclear power reactors. Included was a presentation on environmentally assisted cracking of nickel alloys (Alloys X750, 182, and 600) presented by Peter Andresen from General Electric Global Research. The effects of noble metal chemical addition on crack tip chemistry and mitigation of intergranular stress corrosion cracking in boiling water reactors were also presented.

The Corrosion in Nuclear Systems Symposium also included two papers focused on corrosion of high level waste storage tanks. K. Subramanian presented results of tests conducted to determine the corrosivity of the vapor phase in high level waste tanks at the Westinghouse Savannah River Site. J. Divine presented a case study for one of the tanks at the Hanford site.

The remainder of the papers in the Corrosion in Nuclear Systems Symposium were focused on nuclear waste disposal systems, including 2 papers presented by CNWRA staff and 7 co-authored by Lawrence Livermore National Laboratory (LLNL) staff. Two Alloy 22 stress corrosion cracking papers were co-authored by Lawrence Livermore National Laboratory staff. Very slow crack growth rates were reported by P. Andresen in simulated concentrated water solutions. Under cyclic loading, crack propagation rates were as low as 2×10^{-10} mm/s [8×10^{-12} in/s], which is approximately 60 times the passive dissolution rate. Crack arrest was observed especially at low, constant stress intensities. In constant load tests (Keno tests) using smooth tensile specimens, no crack initiation was observed after extended testing even at stresses as high as 2.5 times the yield strength. Alloy 22 was tested in mill annealed, welded

and thermally aged conditions. It was reported that in many cases severe localized corrosion of the Type 304 stainless steel test fixtures was observed. Corrosion of the test fixtures may have altered the test results because the test specimens were not electrically isolated from the corroding stainless steel. This may have reduced the corrosion potential of the test specimens and prevented the initiation of stress corrosion cracking.

Other results from Lawrence Livermore National Laboratory tests included a presentation of Alloy 22 corrosion potentials by Raul Rebak. The corrosion potential of Alloy 22 was found to be a function of pH and possible nitrate concentration. The corrosion potentials reported in the Lawrence Livermore National Laboratory work were similar to those obtained in tests conducted at the CNWRA.

Two papers were presented by April Pulvirenti from Catholic University of America. The work presented was funded by the Geosciences Management Institute under contract to the Nevada Agency for Nuclear Projects. One paper was focused on the combined effects of chloride and fluoride on the corrosion and stress corrosion cracking of titanium. Nitrate was found to be an inhibitor for localized corrosion of titanium. However, localized corrosion of titanium was observed in dilute solutions containing fluoride and chloride. In the second paper on the corrosion of Alloy 22, very high corrosion rates for Alloy 22 were reported. The test conditions were identical to those reported in the previous Nuclear Waste Technical Review Board Meeting. The Alloy 22 test specimens were exposed to a condensed vapor from boiling simulated concentrated water, or concentrated solutions remaining after the majority of the water had been evaporated.

The Corrosion in Nuclear Systems Technical Committee meeting was held following the symposium. Discussions also included preparation for the Corrosion in Nuclear Systems Symposium at Corrosion/2004.

Environmentally Assisted Cracking

This symposium had a total of 30 scheduled papers but two presentations were cancelled. Most of the papers presented dealt with stress corrosion cracking and hydrogen embrittlement of a variety of materials (aluminum, copper and Al-Mg alloys, carbon and stainless steels) in different applications. Ten papers were related to stress corrosion cracking of pipeline steel, two to alloys used in the nuclear power industry, and three papers were devoted to Alloy 22 in relation to high-level nuclear waste disposal (one of them by the authors of this report). The paper presented by Krisbnan Raja (University of Nevada at Reno) provided data on current transients for Type 304 SS and Alloy 22 in 4 M NaCl solution at 60 °C [140 °F] in an attempt to correlate current values as a function of strain rate with parameters to be used in the modeling of stress corrosion cracking based on the film rupture-slip dissolution model. The validity of the correlations was not clear due to the lack of confirmatory data of the occurrence of stress corrosion cracking a function of potential in the two alloys studied, although the trend in the values appeared reasonable. The paper presented by Raul Rebak (LLNL) provided an update of the work conducted at LLNL. One of the important observations is that no stress corrosion cracking of Alloy 22 was observed under constant deflection using single U-bend specimens of

Alloy 22 in simulated concentrated water under the same environmental conditions and the same anodic potential at which stress corrosion cracking was observed in slow strain rate tests. The different response of the material was attributed to the absence of dynamic straining in the constant deflection tests. However, it was recognized by the author that a more comprehensive evaluation of solution composition and applied potential in the proximity of the values used was necessary to exclude the possibility of stress corrosion cracking by minor variations in environmental conditions. No welded specimens were tested in this study. Although this was the last paper presented in the conference, a substantial discussion followed, reflecting the growing interest in issues related to the evaluation of corrosion processes under the long-term performance envisioned for the disposal of high level waste.

The Environmentally Assisted Cracking Technical Committee meeting was held after the first day of the symposium. It was attended by about 15 people and discussions included preparation for the next symposium at NACE Corrosion/2004, as well as the possible organization of an international conference on the subject to be held tentatively in October, 2004 in Canada.

Microbiologically Induced Corrosion

In this symposium, Joanne Horn (LLNL) presented a paper entitled Comparison of the Microbial Community Composition at Yucca Mountain and Laboratory Test Nuclear Repository Environments. In this paper, the microbiological community structure within the Yucca Mountain repository was evaluated and the microbial growth from collected rock was determined using simulated ground water as a growth medium, with and without amendment of a carbon source. Some of the bacteria from the Yucca Mountain rock were identified to be those known to withstand elevated temperatures and extended periods of dessication (Bacillus, Clostridium, Arthrobacter). Many of the identified Yucca Mountain rock organisms are also well known to maintain activity at extremely low nutrient concentrations (e.g., Caulobacterr). Microbacterium spp., also found within the repository rock, are facultatively fermentative, and thus capable of producing organic acids that may act to accelerate corrosion of engineered barrier subsystem materials.

Research Activities

The Research in Progress Symposium had four sessions. In one of the sessions, chaired by Sean Brossia, a paper was presented by Devendra Gorbe (University de Nevada at Reno) on susceptibility of Alloy 22 to intergranular corrosion. This paper showed the effect of heat treatment time at about 700 °C [1,292 °F] on the anodic behavior observed in single and double loop electrochemical reactivation tests in solutions containing sulfur species and in some cases chloride. Although the effect of aging time on the current parameters was apparent in several solutions, there was no experimental evidence of correlation with microstructural features as hypothesized by the authors.

In the Research Topical Symposium on Modeling and Prediction of Lifetimes for Corrodible Structures several valuable presentations were given by recognized experts in the field. Of particular interest for our program were those of David Shoesmith (University of Western

Ontario) on a Mixed Potential Model to Predict Fuel (UO_2) Corrosion Within a Failed Waste Container and Digby Macdonald (Penn Sate University) on the Mixed Potential-Point Defect Models for Nuclear Waste Containers. Whereas the first presentation dealt with a model of simulated spent fuel dissolution essentially applicable to Candu fuel and the Canadian repository, the approach can be extended to other systems and could be useful to in support of reviews of DOE information. The modeling paper by Macdonald was developed as part of the Yucca Mountain program and contains relevant information on the approach that may be used by the DOE as a technical basis to support the long-term predicted performance of Alloy 22 as related to stable passive dissolution.

Gustavo Cragnolino was invited to participate in the NACE International Research Committee. This invitation was proposed by its chairman David Shoesmith, subject to formal approval.

CONCLUSIONS

The conference provided an opportunity to follow the most recent activities supported by the DOE as well as that of other organizations involved in issues related to Yucca Mountain. Overall, there was increasing visibility and recognition at the meeting of the current corrosion work related to the proposed repository at Yucca Mountain. Technical symposia on monitoring techniques, sensors and electrochemical methods, although not described in detail in this trip report, were attended selectively because specific papers are extremely useful to keep acquainted with recent developments in this field whose importance to performance confirmation and our ongoing research cannot be overlooked.

PROBLEMS ENCOUNTERED

None.

PENDING ACTIONS
None.

RECOMMENDATIONS

Attendance at future NACE CORROSION conference is highly recommended as well as participation in selected technical committees.

SIGNATURES:

P for G. Cragnolino — 4/2/2003

Gustavo A. Cragnolino — Date
Staff Scientist

Darrell S. Dunn — 4/2/2003

Darrell. S. Dunn — Date
Senior Research Engineer

L. Yang

3/28/03

Letai Yang
Senior Research Engineer

Date

Vijay Jain
Manager
Corrosion Science and Process Engineering

3/28/03

Date

CONCURRENCE:

English Pearcy
Manager
Geohydrology and Geochemistry

4/2/2003

Date

GW for B. Sagar

Budhi Sagar
Technical Director

4/2/2003

Date

DD:jg