A Comparison of the Effect of Temperature on the Crevice Breakdown and Repassivation Potentials of Wrought and Welded Alloy 22 in 5 M $CaCl_2$

G. O. Ilevbare

Lawrence Livermore National Laboratory
7000 East Ave, L-631, Livermore CA 94550

Alloy 22 (N06022) is a nickel alloy rich in chromium and molybdenum, with a high degree of corrosion resistance. It exhibits a low general corrosion rate under most conditions and has formidable localized corrosion resistance in most environments compared with other nickel alloys [1-8]. Consequently, Alloy 22 has emerged as the leading candidate for the fabrication of high-level nuclear waste containers, containers which are intended for use for disposal of high-level radioactive waste and spent nuclear fuel. On July 23, 2002, The United States Congress approved the site at Yucca Mountain, Nevada, for development as repository for disposal of these materials.

Since the waste containers will be closed by welding, it is important to fully characterize and understand the electrochemical behavior of the welds and the areas adjoining the welds. One way of doing this would be to compare the behavior of non-welded (wrought) Alloy 22 to that of a welded material to determine whether there is increased susceptibility to corrosion in the welded zones and areas adjacent to the welded zones.

The study of the effect of temperature on the corrosion properties of the alloy is important since during the projected 10,000-year service life, the containers will pass through a heat gradient produced by the nuclear reactions taking place in the waste. Temperatures will be high (above the boiling point of water) in the early service life of the containers, while lower temperatures will prevail much later due to radioactive decay. At this later stage, there is a possibility of ground water contacting the containers.

Highly concentrated chloride-only environments are not representative of Yucca Mountain environments. However, the effect of important individual anions (like Cl^-), which could impact the performance of the containers, must be understood. Crevice corrosion is a concern in Cl^- environments [2-4]. Consequently, the study of the crevice corrosion behavior of Alloy 22 is being carried out in 5 M $CaCl_2$ using a multiple crevice assembly (MCA) sample configuration. This configuration was optimized for the study of crevice corrosion as it provides 24 potential crevice generation sites on a surface area of less than 10 cm^2.

Preliminary results of experiments carried out between 60 and 90°C show that Alloy 22 was susceptible to localized corrosion in 5 M $CaCl_2$ electrolyte at temperatures as low 60°C. Figure 1 shows a plot of corrosion potential (E_{corr}), and critical crevice breakdown potential (E_{crit}) as cumulative probability plots. Within this 30-degree temperature range, E_{corr} varied over a range of 80 mV. The susceptibility of Alloy 22 to crevice corrosion was found to increase with increase in temperature. Experiments are ongoing to determine E_{crit} at temperatures between 45 and 120°C, for wrought and welded samples.

References

1. G.O. Ilevbare T. Lian and J.C. Farmer, Paper No. 02539, Corrosion 2002.
2. G.O. Ilevbare, Transportation Storage, and Disposal of Radioactive Materials, PVP-Vol. 449, p.55 2002. American Society of Mechanical Engineers (ASME), New York, USA.
3. B. A. Kehler, G.O. Ilevbare and J.R. Scully Corrosion, 57, pp. 1042, 2001.
4. B. A. Kehler, G. O. Ilevbare and J. R. Scully Corrosion 2001, Crevice Corrosion Behavior, of Ni-Cr-Mo Alloys: Comparison of Alloys 625 and 22, NACE Topical Research Symposium, p.30, March 2001.
5. Haynes International, Inc., Product Brochure H-2019E, Haynes International Inc. Kokomo, IN, p.22, 1997.
6. J. C. Farmer, D. McCright, G.E. Gdowski, F. Fang, T. Summers, P. Bedrossian, J. Horn, T. Lian, J. Estill, A. Lingenfelter, and W. Halsey, General and Localized Corrosion of Outer Barrier of High-Level Waste Container in Yucca Mountain, May 2000. Preprint UCRL-JC-138890, Lawrence Livermore National Laboratory, Technical Information Department Digital Library.
7. K.A. Gruss, G.A. Cragnolino, D.S. Dunn and N.Sridhar, Corrosion '98, Paper No. 149, 1998.
8. S.J. Lukezich, The Corrosion Behavior of Ni-Base High Performance Alloys in Simulated Repository Environments, MS Thesis, The Ohio State University 1989.

Acknowledgements

The Department of Energy Office of Civilian Radioactive Waste Management (OCRWM) sponsored this work. This work was done under the auspices of the U.S. Department of Energy (DOE) by the University of California, Lawrence Livermore National Laboratory (LLNL) under contract No. W-7405-Eng-48. This work is supported by Yucca Mountain Site Characterization Project, LLNL. Technical comments were provided by R. Daniel McCright and R. B. Rebak.

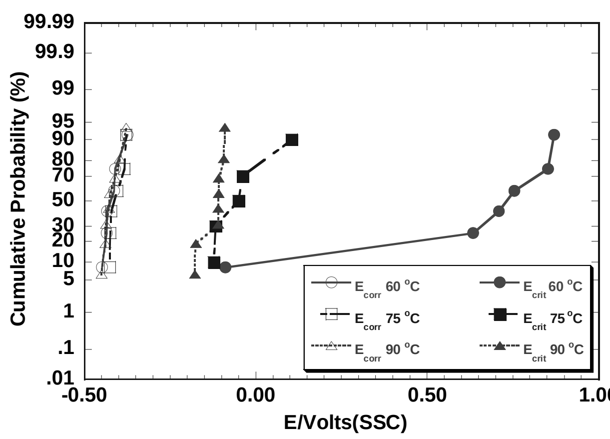

Figure 1. Corrosion potentials (E_{corr}) and crevice breakdown potentials (E_{crit}) of Alloy 22 plotted as cumulative probabilities in 5 M $CaCl_2$ at 60, 75 and 90 °C. The crevice breakdown potential E_{crit} was taken as the potential that coincided with the onset of the first permanent rise in current density from the passive region. At 60 °C data due to localized breakdown were not separated from those due to transpassive dissolution.