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Stress Corrosion Cracking of Alloy 22

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The U.S. Department of Energy selected Alloy 22 as the waste package outer container material for long-term disposal of high-level nuclear waste at the potential Yucca Mountain repository, because of its excellent resistance to general corrosion as well as to localized corrosion in the potential Yucca Mountain repository environment [1,2]. Stress corrosion cracking (SCC) is one of the most likely degradation modes for the waste package and drip shield materials. We have modified deterministic codes that incorporate models and algorithms for describing the electrochemistry of the environment and the growth of stress corrosion cracks (via the Coupled Environment Fracture Model, CEFM) to predict crack growth rate in Alloy 22 in saturated NaCl solutions. Modification involves optimization of the CEFM on experimentally measured *CGR* data taken from the literature, as shown in Figure 1. The modified CEFM provided for the quantitative prediction of the effects of temperature, electrochemical corrosion potential, conductivity, stress intensity factor, and electrochemical crack length, as well as explaining the development of semi-elliptical surface cracks. Note that perforation of the waste package outer container occurs, because of crack growth perpendicular to the wall of outer, corrosion-resistant sheath of the waste package, the rate of which depends upon the electrochemical crack length. It is crack growth in this direction that ultimately may result in the failure of the corrosion-resistant sheath of the waste package container. In this paper, the crack lengths perpendicular to and along the surface wall are predicted with respect to elapsed time, as shown in Figure 2. It is assumed that a constant load is applied over the selected time. It should be stressed that, because the present calculations assume an active, preexisting crack, no account of initiation is incorporated into the model. A service life of about 1057 years after the initiation of surface crack is estimated.

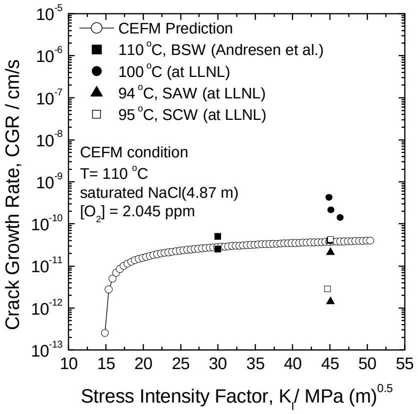

Figure 1. Plots of the experimental data and calculated CGR as a function of K_I for Alloy C22 in saturated NaCl solution (4.87 m), at 110 °C. BSW is basic saturated well water (pH ≈ 11 - 13), SAW is simulated acidic well water (pH ≈ 2.7), and SCW is simulated concentrated well water (pH ≈ 8.5 - 9.0).

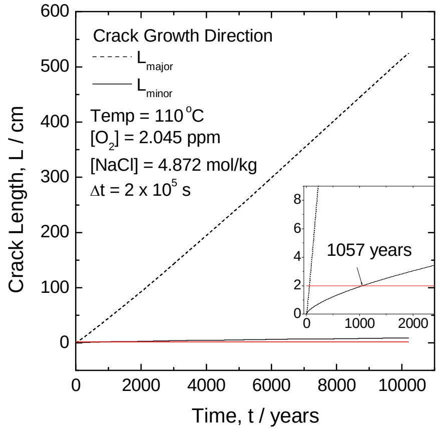

Figure 2. Predicted crack lengths perpendicular to the surface (L_{minor}) and along the surface (L_{major}) with respect to elapsed time for Alloy 22 in saturated NaCl solution at 110 °C.

[1] DOE, DOE/RW-539, "Yucca Mountain Science and Engineering Report," Las Vegas, Nevada, Office of Civilian Radioactive Waste Management, May 2001.

[2] G.M. Gordon, "F.N. Speller Award Lecture: Corrosion Considerations Related to Permanent Disposal of High-Level Radioactive Waste", Corrosion, 58 (10) (2002) 811–826.