

Comparison of the Crevice Corrosion Resistance of Alloys 625 and 22

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Introduction

The Yucca Mountain Site Characterization Project is concerned with the corrosion resistance of candidate engineered waste package materials. A variety of waste package designs have been proposed for US and Canadian High Level Nuclear Waste Repositories. A common feature of each design is the possibility of utilizing a corrosion resistant material such as a nickel-based super alloy or titanium-based alloy. A suitable corrosion resistant material may provide (a) kinetic immunity if the combination of repository environmental conditions and alloy resistance assure both: (i) a passive condition with negligible chance of localized corrosion stabilization, as well as (ii) low enough passive dissolution rates to insure conventional corrosion allowance over geological times, (b) a second form of "corrosion allowance," if it can be scientifically demonstrated that a mechanism for stifling (i.e., death) of localized corrosion propagation occurs well before waste canisters are penetrated, or (c) such a low probability of initiation and continued propagation that a tolerably low degree of penetration occurs.

Unfortunately, a large database on the crevice corrosion properties of alloy 22 does not exist in comparison to alloy 625. Alloy screening tests in oxidizing acids containing FeCl_3 indicate that alloy 22 is more resistant to crevice corrosion than 625 as indicated by critical pit and crevice temperatures. Differences in alloying element compositions as expressed by pitting resistance equivalency number calculations support these findings. However, these data only provide the relative ranking of these alloys in terms of crevice corrosion and do not answer the critical questions proposed above.

Objective

In this preliminary study, we address the issue of whether differences in reported localized corrosion susceptibility derive from differences in conventional critical potentials for crevice stabilization and repassivation. Long-range goals include understanding whether differences derive from changes in initiation rates during the

metastable stage, stabilization rates, propagation rates, crevice corrosion survival rates, or other factors. A second long-term goal is to develop functional relationships between such rates and the applied potential, temperature, and solution composition.

Procedures

Alloy 625-UNS number N06625 (Ni: 61.97, Cr: 21.56, Mo: 8.95, Fe: 3.40, balance: minor constituents, wt%) and alloy 22-UNS number N06022 (Ni: 56.90, Cr: 21.58, Mo: 12.79, Fe: 3.90, W: 2.79, balance: minor constituents, wt%) in a solution-annealed condition were studied to determine the effects of temperature, electrolyte composition, and surface finish on crevice corrosion. The face of the sample was placed inside a crevice assembly consisting of ceramic multiple crevice formers lined with polytetrafluoroethylene (PTFE) tape. This arrangement created a reproducible tight crevice. Experiments were conducted in 5 M LiCl electrolytes at temperatures ranging from 60° to 100°C. Sodium sulfate and sodium nitrate were added in concentrations to yield electrolytes with ratios of chloride ions to total oxyanions of 10:1 and 100:1. Cyclic potentiodynamic polarization scans were performed using a polarization rate of 0.05 mV/sec starting at 50 mV below the open circuit potential to determine critical crevice stabilization (E_{crev}) and repassivation potentials ($E_{\text{r,crev}}$) using conventional current density thresholds. Other electrochemical tests were performed to distinguish localized corrosion from O_2 evolution and Cr (Mo, Ni) transpassivity.

Results

Reported crevice stabilization (E_{crev}) and repassivation potentials ($E_{\text{r,crev}}$) are shown for alloy 625 as a function of temperature and halide content. Data from three separate investigations on 625 are summarized in Figure 1. All potentials have been converted to the NHE scale at room temperature. Clearly, E_{crev} and $E_{\text{r,crev}}$ depend significantly on temperature, and halide content. In particular, the ratio of halide content to oxyanions such as sulfate and nitrate are important factors. Note that changing the ratio of chloride ions to the sum of all oxyanion molarities from 100/1 to 10/1 at a fixed 5 M Cl⁻ concentration raises E_{crev} but negligibly affects $E_{\text{r,crev}}$. Similar trends were observed for alloy 22.

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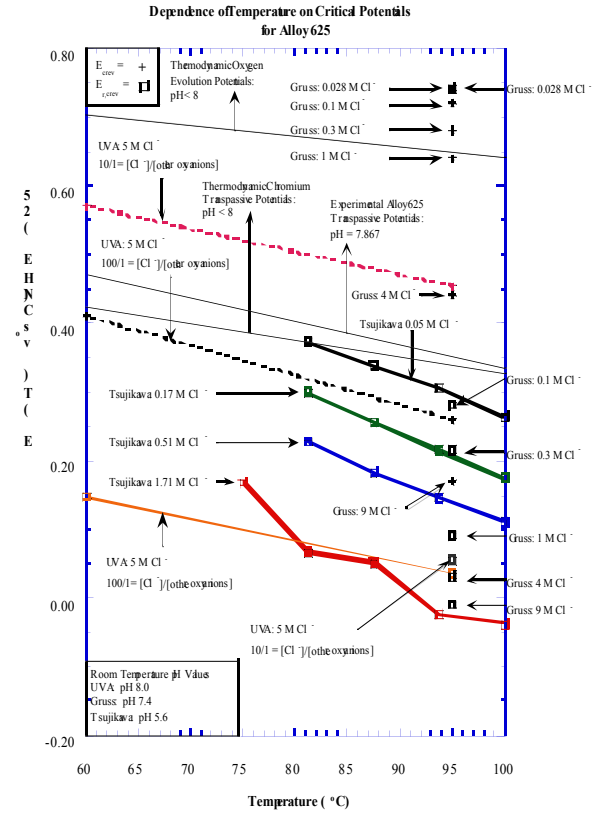


Figure 1. Dependence of critical crevice potentials on temperature and electrolyte for alloy 625.