

Quantitative Analyses of the Severity of Attack on Crevice Corrosion Samples with Rigorously Controlled Crevice Dimensions

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The analysis of the results of crevice corrosion testing for corrosion resistant metals has primarily been qualitative. The main challenges in quantification of crevice corrosion damage can be classified into a need for a method of damage quantification that allows the spatial distribution of damage to be captured and the difficulties in reproducibly producing crevice samples with known gaps and lengths.

Due to the localized nature of crevice corrosion attack, mass loss measurements must be interpreted with great care. In addition, such measurements provide very limited information regarding the spatial distribution of the damage which can be of critical importance to evaluating the effects of the corrosion on structural integrity. Measurements of the evolution of the dissolution current can be of great use in the determination of the onset, stabilization, and stifling of crevice corrosion, but usually lack the ability to discriminate spatial variations, although recent work with multiple electrode assemblies have made progress in that area¹ by using individually addressable wire electrodes packed into an assembly which is then creviced. For continuous metallic surfaces, the application of confocal laser scanning microscopy (CLSM) to crevice corroded surfaces has been shown to allow quantitative examination.² Figure 1 shows an example of the topographical map of a footprint from sample KE0103 which was tested with an applied potential of +0.1V (SCE) in a solution of 6m NaCl + 0.9m KNO₃ for 168 hrs. In addition to the total volume lost, profiles of damage can also be extracted.

Even with the ability to quantitatively analyze corrosion damage, there remains the challenge of creating crevices with dimensions that are uniform across the crevice and controllable. Such control is important in creating reproducible experiments probing the critical factors as well as in the comparison of such results to those of computational models which have always assumed the presence of a uniform crevice gap over the entire crevice surface. Currently, the most popular experimental arrangement for creating crevices is the application of use of deformable materials (e.g., PTFE) onto a metal surface with a known applied pressure. The multiple crevice assembly (MCA) extends this approach by using two rings of 12 individual feet which are contacted to the metal of interest and tightened in place to a desired torque. Although this approach produces 24 crevices for each test, there is substantial ambiguity with respect to the crevice dimensions such as the length of the crevice and size of the gap. Recently, the manufacture of crevice formers via microfabrication techniques has been shown to allow much tighter controls of crevice dimensions.³ By applying these crevice formers with gaps of between 7.3 and 400 microns to Ni200 samples, computationally-derived scaling laws for IR-induced crevice corrosion were experimentally validated including the effects of a finite crevice length as shown in Figure 2.³

In the present work, Ni-Cr-Mo alloy crevice samples were created with crevice gaps varying from 0.1-1 μ m and crevice lengths varying from 2-10 mm. Polarization curves were generated for different conditions and the morphology of the resulting surfaces were studied quantitatively using the CLSM. Electrochemical parameters such as repassivation potential and total charge passed were recorded and morphological features such as maximum depth of attack and volume

lost were measured. The effects of crevice geometry, temperature, and bulk solution composition were evaluated. These results will be compared to the effects expected from scaling laws, and the implications for the stability of crevice corrosion discussed.

Acknowledgements

Support by the Office of Science and Technology and International of the U.S. Department of Energy (DOE), Office of Civilian Radioactive Waste Management is gratefully acknowledged. The work was performed under the Corrosion and Materials Performance Cooperative, DOE Cooperative Agreement Number: DE-FC28-04RW12252. Samples of corroded Alloy 22 were provided by R. Rebak, Lawrence Livermore National Laboratory.

References

1. F. Bocher, F. Presuel-Moreno, N.D. Budiansky, F.R. Scully, *Coupled Multi-Electrode Investigation of Crevice Corrosion of 316 Stainless Steel*, CORROSION/06, RIP Symposium, San Diego, March, 2006.
2. A.J. Hodges, R. G. Kelly, *Quantitative Analyses of the Severity of Attack on Crevice Corrosion Surfaces*, CORROSION/06, RIP Symposium, San Diego, March, 2006.
3. J.S. Lee, M. L. Reed, R. G. Kelly, *J. Electrochem. Soc.*, 151 (7), B423-B433 (2004).

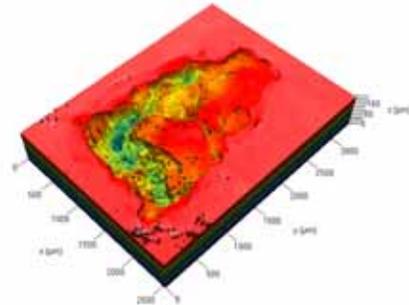


Figure 1: Footprint from sample tested at an applied potential of 0.1V_{SCE} in 6m NaCl + 0.9m KNO₃ for 168 hrs. The volume lost was 0.143 mm³ and the maximum depth of attack was 154 μ m.

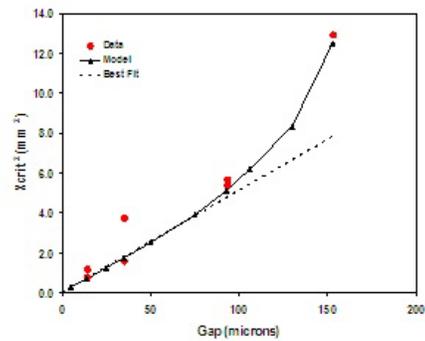


Figure 2: Plot of critical crevice distance as a function of gap size where the critical crevice distance is the distance into the crevice where initiation took place.

