

## Coupled Multi-Electrode Investigation of Crevice Corrosion of 316 Stainless Steel and NiCrMo Alloy 625

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Crevice corrosion is currently mostly studied using either one of two techniques depending on the information desired. The first method involves two multi-crevice formers or washers fastened on both sides of a sample plate. This technique provides exposure information regarding the severity of crevice corrosion (depth, position, frequency of attack) but delivers little or no electrochemical information.<sup>1</sup> The second method involves the potentiodynamic or potentiostatic study of an uncreviced sample in a model crevice solution or under a crevice former in aggressive solution where crevice corrosion may initiate and propagate and global current is recorded.<sup>2</sup> However, crevice corrosion initiation and propagation behavior is highly dependent on exact position in the crevice over time. The distance from the crevice mouth will affect the solution composition, the pH, the ohmic potential drop and the true potential in the crevice. Coupled multi-electrode arrays (MEA) were used to study crevice corrosion in order to take in account spatial and temporal evolution of electrochemistry simultaneously.

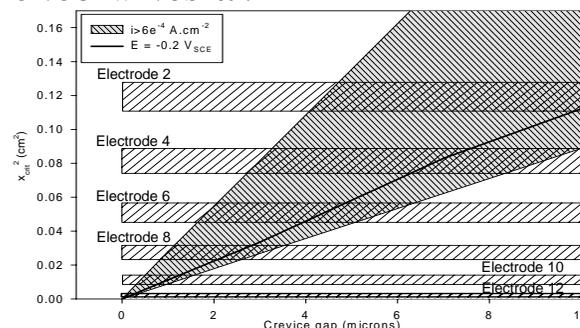
Scaling laws were used to rescale the crevice geometry while keeping the corrosion electrochemical properties equivalent to that of a natural crevice at a smaller length scale. One of the advantages was to be able to use commercial alloys available as wires electrode and, in the case of MEA, to spread the crevice corrosion over many individual electrodes so each one of them will have a near homogeneous electrochemical behavior. The initial step was to obtain anodic polarization curves for the relevant material in acid chloride solution which simulated the crevice electrolyte. Using the software Crevice<sup>TM</sup> 3, 4, the potential distribution inside the crevice as a function of the distance from the crevice mouth was determined for various crevice gaps and applied potentials, assuming constant chemistry throughout the crevice. The crevice corrosion initiation location  $x_{crit}$  is the position where the potential drops to  $E_{Flade}$ . Figure 1 illustrates the resulting  $x_{crit}^2$  vs.  $G$  scaling laws for 316 Stainless Steel in 1 M HCl at 50°C.

The coupled multi-wire array is composed of one hundred identical 316 Stainless Steel wires in a five by twenty formation inserted in a groove of a 316 Stainless Steel rod such that the ends of the wires are flush mounted with the rod. The 100 wires are coupled electrically through in-line zero resistance ammeters. The diameter of the wires (250  $\mu\text{m}$ ) was chosen so that  $x_{crit}$  (critical initiation distance from the crevice mouth) and the expected zone of crevice corrosion (predicted from the scaling law) would be larger than the radius of a single wire. The array created a flush mounted planar electrode with the surface/volume ratio obtained in planar crevices. The observation of the current evolution as a function of position inside and outside the crevice as function of time was made possible as illustrated in Figure 2 in 0.6 M NaCl at 50°C.

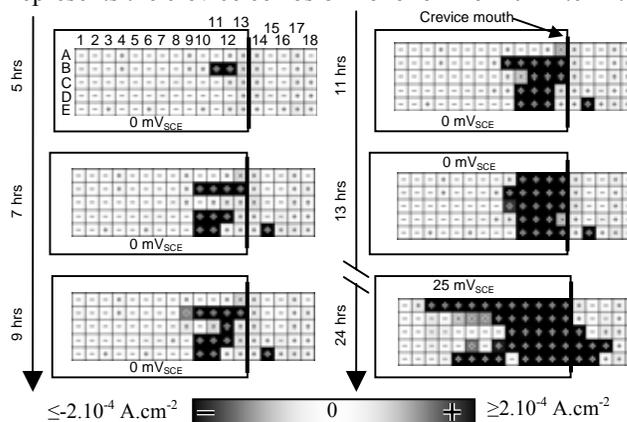
From the current measurements, it is possible to follow the progress of the location, rate and depth of crevice corrosion attack. The MEA also allows the study of crevice corrosion propagation, stifling, as well as the manner in which the corrosion sites rearrange in response to various realistic conditions. Recently developed EIS capable MMA offers the chance to follow the passive film evolution especially during the initiation of crevice corrosion. On-going experiments will be discussed.

### Acknowledgements

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**Figure 1.**  $x_{crit}^2$  vs. crevice gap scaling law model based on anodic polarization data. The horizontal blocks represent the position of the electrodes of an array at different positions (Figure 2 nomenclature). The shaded area represents the crevice corrosion zone for  $i > 6 \cdot 10^{-4} \text{ A.cm}^{-2}$ .



**Figure 2.** Evolution of crevice current density for 316 stainless steel array in 0.6 M NaCl at 50°C showing the initiation and propagation of crevice corrosion at 0  $\text{mV}_{\text{SCE}}$  and 25  $\text{mV}_{\text{SCE}}$ . Each square represents an individual electrode current density according to the scale. The electrodes covered with the crevice former are within the large black rectangle (not to scale).

### References

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