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Examination of Corrosion Products and the Alloy Surface after Crevice Corrosion of a Ni-Cr-Mo Alloy

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The objective of this study is to investigate the composition of corrosion products and the metal surface within a crevice after localized corrosion. The analysis provides insight into the propagation, stifling and arrest processes for crevice corrosion and is part of a program to analyze the evolution of localized corrosion damage over long periods of time, i.e. 10,000 years and longer [1]. The approach is to force the initiation of crevice corrosion by applying anodic polarization to a multiple crevice assembly (MCA) [2]. Results are reported here for alloy C-22, a Ni-Cr-Mo alloy, exposed to a high temperature, concentrated chloride solution.

Controlled crevice corrosion tests were performed on C-22 under highly aggressive, accelerated condition, i.e. 4M NaCl, 100°C and anodic polarization to -0.15V-SCE. The crevice contacts were by either a polymer tape (PTFE) compressed by a ceramic former or by a polymer (PTFE) crevice former. Figure 1 shows the polarization current during a crevice corrosion test. After an incubation period, several initiation-stifle-arrest events were indicated. The low current at the end of the test indicated that the metal surface had repassivated.

After exposure, loose black corrosion product was found under the crevice formers, and green deposits were around the edges of the crevice contacts. During the exposure, the color of the test solution changed from clear to light green. The corrosion products and the metal surface were analyzed by SEM/EDS, AES and XPS for indications of uniform, non-selective dissolution; selective dissolution; or surface enrichment. Figure 2 shows SEM photomicrographs corrosion beneath a crevice contact area. The compositions corrosion products at locations A-D are compared to the nominal composition of C-22 in Table 1. The EDS results show that compared to the un-corroded area A, D, the corrosion products are rich in O, enriched in Mo and W, and depleted in Ni and Cr. This is consistent with the greater stability of oxides of Mo and W than Ni and Cr in reducing, strongly acidic solutions.

The metal surface composition was determined by AES depth profiles after loose corrosion products had been removed. Sites of varying corrosion penetration were analyzed, and figure 3 presents the depth profile of the metal surface after approximately 60 µm corrosion penetration. The results are interpreted to indicate a chromium oxide barrier film on the alloy surface. The approximately 2-8 nm thick barrier layer is responsible for the repassivation within the crevice. After 10's µm of crevice corrosion penetration, a thin (several nm) zone of Ni enrichment and Cr depletion within the metal was observed; however, on the micro/macro scales, the alloy dissolution occurred by a uniform, non-selective dissolution.

These results are combined with those from collaborative studies, e.g. 3-D reconstruction of corrosion, critical crevice chemistry measurements and modeling of damage evolution, to better understand crevice corrosion.

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References:
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2. ASTM International, Annual Book of ASTM Standards, Volume 03.02 G48-03, Standard Test Methods for Pitting and Crevice Corrosion Resistance of Stainless Steels and Related Alloys by Use of Ferric Chloride Solution, West Conshohocken, PA (2005)

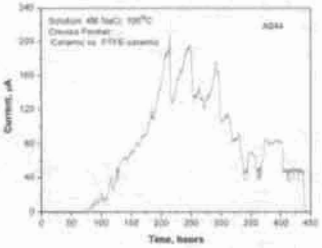

Figure 1 Polarization current with time during crevice test

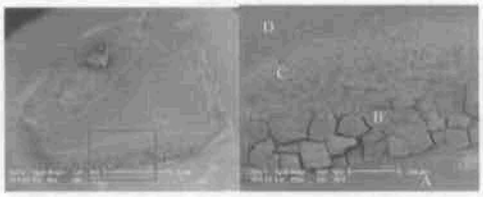

Figure 2 Corrosion beneath a crevice contact area.

Table 1 EDS analysis at locations A-D above (at%)

	Cr	Mo	W	Fe	O	Ni	Ni/Cr	Mo/Cr	W/Cr
A	23.3	7.8	1.0	5.2	8. 5	54.3	2.3	0.33	0.04
B	7.9	20.8	3.3	0	67.2	0.8	0.1	2.6	0.41
C	21.8	7.4	0.8	5	12.7	52.4	2.4	0.34	0.04
D	19.9	7.7	1.3	4.2	22.7	44.4	2.2	0.39	0.07
C- 22	26.1	8.3	1	3.3	n/a	58.7	2.2	0.32	0.04

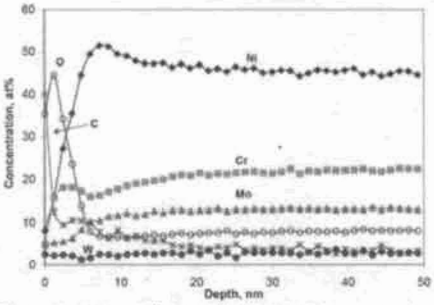

Figure 3 AES profiles on metal after 60 µm corrosion penetration in the creviced area