

THE TRANSITION FROM LOCALIZED CORROSION TO SCC OF AL-Li-Cu Alloy AA2096 AS A FUNCTION OF ISOTHERMAL AGING HEAT TREATMENT AT 160°C

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An investigation was conducted to understand the electrochemical and metallurgical processes governing the transition from localized corrosion attack to SCC initiation involved in Al-Li-Cu alloy AA2096 as a function of isothermal aging heat treatment. SCC screening conducted on bluntly notched specimens in 0.6 M NaCl alternate immersion revealed two distinct and separate windows of IGSCC susceptibility as a function of temper. Stress corrosion failure in susceptible tempers involved pitting, pit coalescence to form fissures, intergranular corrosion within fissures and stress corrosion cracking.

Diagnostics were performed to elucidate whether differences in localized corrosion behavior and/or IGSCC susceptibility as a function of temper influenced the overall susceptibility to SCC initiated from smooth specimens. Serial time exposures in the alternate immersion environment enabled documentation of localized corrosion site evolution in terms of corrosion type and resultant geometry. The evolution consisted of several distinct stages: pit initiation at constituent particles, coalescence of corrosion sites along bands of constituent particles forming corrosion fissures, and intergranular/inter-subgranular corrosion at the base of these fissures in SCC susceptible tempers. Stress corrosion cracking occurred at the base of these corroded regions. All tempers pitted or formed cathodic trenches at constituent particles and, subsequently, formed elongated corrosion fissures, but the transition to corrosion at metallurgical interfaces / intergranular cracking was controlled by a complex combination of metallurgical susceptibility, chemistry development, and stress. The importance of the differing corrosion site evolution as a function of temper was a subject of focus to determine whether it was a governing factor in SCC initiation and overall SCC susceptibility in a smooth or notched specimen. The differing localized site dimensions (geometries) as a function of applied remote stress and temper were qualitatively analyzed. It was observed that bigger, deeper corrosion fissures form along bands of constituent particles in SCC susceptible tempers due to stress assisted inter-subgranular induced localized corrosion site coalescence. It was, therefore, proposed that stress intensities due to differing geometries developed from differing localized corrosion site evolution contribute strongly to SCC initiation and subsequent SCC susceptibility in smooth or notched specimens as a function of temper.

Electrochemical testing defining critical potentials of alloy phases (i.e., second phase precipitates, solute depleted zones) as a function of temper was performed to explain the differences in localized corrosion site evolution as a function of temper. Specifically, the susceptibility to intergranular corrosion and subsequent IGSCC was investigated according to an electrochemical framework for preferential grain boundary dissolution. Emphasis was placed on investigation of possible boundary copper depleted zone versus anodic T₁ particle dissolution on or adjacent to low angle sub-grain boundaries. Metallurgical analysis via TEM verified eligibility

of these preferential dissolution theories as a function of temper. Hence, even though all tempers were susceptible to pitting associated with constituent particle bands, pits in SCC susceptible tempers transitioned into intergranular corrosion sites due forming more elongated, deeper corrosion fissures. Specifically the electrochemical framework for underaged tempers implicated Cu-depletion to create susceptible grain boundary paths. Susceptibility in overaged tempers was consistent with more continuous T and S type particle precipitation. The dimensions of these fissures including any emanating intergranular corrosion sites increased applied stress intensity that, in part, governs SCC initiation and subsequent SCC susceptibility. Future work will be directed toward further understanding of stress assisted localized corrosion site coalescence and growth.

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References

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