Environment-Induced Crack Initiation and Early Stages of Crack Growth in Aluminum Alloys

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Our comprehensive historical review of the environment-induced cracking (EIC) of aluminum alloys over the last 80 years revealed that minimal attention has been focused on the initiation and early stages of crack development both for test samples and more importantly for aerospace structures constructed from AA7xxx alloys during either material development or during field exposure in service.[1] This has led to both uncertainties for the development of reliable test methods, alloy and temper selection, and fabrication and joining methodologies that do not provoke EIC. Together this has resulted in repeated incidences of major service failures over the years.[1]

The high-strength Al-Zn-Mg-Cu plate alloys, such as AA7050 and AA7010, used widely during the 1990s and the following two decades in aerospace applications, suffered little or no EIC during service use. These alloys were designed to provide “practical immunity” to EIC during use in structural aerospace applications, following lessons learned from the EIC issues experienced with earlier alloys and tempers, e.g., AA7079 and AA7075.[1] However, aerospace structures fabricated from the latest generation alloys, e.g., AA7085, AA7449, etc., have suffered EIC during service.[2]

It is now better understood that the EIC performance of high-strength Al-Zn-Mg-Cu alloys during service use are not controlled by the crack growth rates within the stress intensity K-insensitive region associated with long/deep cracks, which may be of the order of mm/y. It is the ability to resist EIC growth following initiation and early stages of crack growth ahead of establishing suitable conditions for stress-intensity insensitive crack growth that is responsible for the major part of the performance enhancement.

This realization led us to develop a themed issue consisting of a series of “state-of-the-art” contributions by invited researchers. These articles provide a well-informed overview, together with a critical assessment of the current understanding of EIC initiation and early stages of crack growth in aluminum alloys.

We consider that the contributions, presented as sections in two issues of *CORROSION* published in 2023, fulfill this objective and in addition provide guidance toward improved EIC assessment methods, as well as the direction for future alloy development.

The first section, presented herein, includes the history of EIC during commercial use of aluminum alloys, with a discussion on future aluminum alloy development and EIC assessment.[1] It also includes an examination of the use of local probe techniques to study processes occurring at intermetallic particles with implications at EIC initiation[3] and a study using “4D” x-ray microtomography to explore initiation and growth of pits as well as the effect of testing.[4] Rounding out the section is an article that investigates recommended testing conditions for 7xxx series aluminum alloys used in aerospace applications.[5] In this article, it is clear that comparisons of stress corrosion cracking performance of alloy compositions should be made wherever possible at identical plate thickness and for aging treatments that result in comparable strengths. These trends suggest that similar repeated initiation and propagation mechanisms are responsible for cracking in both humid air and aqueous NaCl environments.

We are certain that the articles herein capture the state-of-the-art in test methods and theories pertinent to EIC initiation and the highly stress-dependent early stages of EIC. The readership of *CORROSION* should find these manuscripts of enduring value.

References

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