EXPERIMENTAL STUDIES OF ENVIRONMENT-INDUCED CRACK INITIATION IN METALS

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Despite the many publications over the years on the Environment-Induced Cracking (EIC) of ferrous and non-ferrous alloys, surprisingly few specifically address crack initiation under experimental conditions relatable to those experienced during commercial usage where frequently this is the controlling influence determining life for use in structural applications.

We have summarized the literature on EIC initiation published over the past 70 years, that was occasionally disregarded particularly if it was not written in English. A rationale is offered how metallic alloys susceptible to significant EIC propagation rates when simultaneously subjected to sufficient mechanical driving forces and local environmental conditions can provide adequate long-term service performance.

EIC initiation typically involves at least three stages, including: incubation, stress enhanced growth that may ‘arrest’ and a transition to stable propagation, if local environmental conditions remain appropriate and the applied mechanical driving force exceed a threshold, often described by a stress intensity factor, K_{IEIC}.

Early researchers understood that surface conditions could influence EIC initiation behavior and typically used either electropolished or carefully mechanically polished surfaces for their studies, unlike more contemporary studies, where standard surface grinding or machining procedures are widely used for comparative assessments of EIC susceptibility and such approaches have been standardized. However, these ‘artificial’ alloy surface conditions are rarely representative of those developed during use in commercial service applications, fail to provide beneficial influences, such as a disruption of immediate sub-surface microstructure to generate ‘disturbed’ layers that can strongly influence EIC initiation and crack arrest.

Alloy developers, product designers and commercial users need quantitative EIC initiation and growth data from accelerated laboratory testing that is directly relatable to actual surface conditions and the expected service environment. We now have advanced experimental techniques that mean we are now well-placed to examine the EIC initiation phenomena as never before.