Overview: Section 4

Test Methods for Ranking Relative Susceptibility of Alloys to Hydrogen Damage

Can any short-term test method be trusted to predict 20+ years of service damage in a hydrogen environment? Is it better to accelerate such tests by raising the hostility of the environment out of all recognition to reality, or increasing the stress intensity beyond any reasonable engineering level? How does one rate test methods for their balance between cost-effectiveness and predictive power? These are the sort of questions we must consider.

A low-alloy steel for landing gears, with hardness of HRC 55, a submarine hull steel of HRC 34, and a pipeline steel of HRB 85 have little in common despite their small differences in composition. Strength, toughness, and fabricability are so far apart that calling all three members the same alloy family is more confusing than useful.

If there is a common factor among the three alloys cited, it is their susceptibility to hydrogen-induced cracking. All three alloy types suffer from different manifestations of the problem within their particular application and environment.

Consider the range of hydrogen-induced cracking mechanisms in low-alloy steels:

Hardness Range	Mechanism	Test Methods
HRC 38 to 55	H_2 embrittlement	ASTM F 519
HRC 32	Stress corrosion	ASTM G 44
HRC 22	Sulfide stress cracking	NACE TM-01-77
Any	Step-wise cracking	NACE TM-02-84

Within the broad bands of hardness suggested above, there are still variations in relative resistance due to a complex interaction of composition and thermal history. The standard test methods listed above were developed to rank and sort materials within their alloy classes in relationship to particular applications and possible fracture mechanisms.

Given the vast difference in hydrogen availability between an electrolytic plating operation and 20 years' service in an H_2S-bearing gas pipeline, no universal test method for hydrogen cracking seems feasible. The challenge materials engineers face is to develop cost-effective test methods with the broadest possible applicability to different alloys being considered for a given environment.

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