AMPP TM21451-2023
Approved March 6, 2023

Evaluation of Carbon and Low-Alloy Steels for Resistance to Stress-Oriented Hydrogen-Induced Cracking (SOHIC)

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Document History:

2023-03-06: Approved by AMPP Standards Committee (SC) 08, Metallic Material Selection & Testing

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Foreword

Carbon and low-alloy steels in plate form and their welded products may be susceptible to one or more forms of environmental cracking when exposed to wet H_2S service conditions. These include, for example, (1) sulfide stress cracking (SSC) of hard zones and welds; (2) hydrogen-induced cracking (HIC) in the parent metal; and (3) stress-oriented hydrogen-induced cracking (SOHIC) in the region adjacent to welds of nominally acceptable hardness. Extensive work has been conducted over many years to understand various fundamental and applied aspects of these phenomena. Experiences in refinery wet H_2S operations have directed particular attention to understanding SOHIC and the various metallurgical and environmental parameters that govern its occurrence.

Scope

This standard was prepared to provide a test method for consistent evaluation of pipeline and pressure vessel steels to SOHIC caused by hydrogen absorption from aqueous sulfide corrosion. The test conditions are not designed to simulate any specific service environment. The test is intended to evaluate resistance to SOHIC only, and not to other adverse effects of sour environments such as sulfide stress cracking (SSC), pitting, or mass loss from corrosion.

Rationale

A number of AMPP technical publications[1-6] and technical reports have focused on several issues related to the serviceability of carbon steel equipment in wet H_2S service. One of these issues is the evaluation of steels to determine their resistance to SOHIC. Other test methods have been standardized for evaluation of SSC and HIC; NACE Standards TM0177, TM0316, and TM0284 are extensively utilized in the evaluation and qualification of steels for determination of resistance to SSC and HIC respectively. However, none of these test methods deals directly with the specific mechanism and mode of cracking inherent to SOHIC.

The following situation illustrates the shortcomings of the existing test methods in the evaluation of SOHIC. Cracking observed in steel equipment resulting from SOHIC appears to be mechanistically related to HIC because it involves the formation of small HIC cracks in the steel (from the recombination of atomic hydrogen to molecular hydrogen) and the development of interconnecting cracks that link adjacent HIC cracks on different planes in the steel. The small cracks characteristic of HIC typically form parallel to the plate surface (see Figure 1).