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Laboratory Testing for Resistance to Environmentally-Assisted Hydrogen Stress Cracking in Welds

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FIGURES

TABLES

Foreword

This standard addresses the testing of welds for resistance to cracking failure under the combined action of tensile stress and environmentally generated and charged hydrogen which ingresses into the weld during service. This phenomenon is generally termed environmentally induced hydrogen stress cracking when operating at ambient or low temperature. For the purposes of this standard, environmentally assisted cracking (EAC) includes only hydrogen stress cracking (HSC).

When hydrogen atoms are evolved on the surface of a metal or weld by corrosion or cathodic charging, they enter the metal or weld and diffuse to regions of high triaxial tensile stress or to some microstructural configurations where they become trapped and decrease the ductility of the welded joint. Although there are several kinds of cracking damage that can occur in metals and their welds, delayed brittle fracture of metals resulting from the combined action of hydrogen charging and tensile stresses is known as HSC.

Certain ASTM and NACE standard test methods have been listed as references for supplementary tests, creating a comprehensive test method standard. This standard is intended for use by laboratory and materials personnel to facilitate conformity in testing. HSC of welds exposed to cathodic protection while in subsea environments is widely recognized as a possible damage mechanism. Laboratory data and field experience have demonstrated that while extremely rare, failures of welds susceptible to HSC can occur, if directly exposed to a hydrogen charging source, even at applied loads well within design conditions. However, laboratory and operating experiences have also indicated to materials engineers the optimum selection and specification of welding solutions having minimum susceptibility to HSC. This standard covers a test method for HSC at ambient and low (subsea) temperature.

The primary purpose of this standard is to facilitate conformity in testing so that data from different sources can be compared on a common basis. Consequently, this standard aids the evaluation of all types of metals and alloys and welding processes, regardless of their form or application, for service in hydrogen charging environments. This standard contains methods for testing metals using specially designed tension test specimens.[1,2] The design is to allow for a large area of the weld zone to be evaluated while reducing the stresses due to test specimen edges to allow the most sensitive region of the weld to be evaluated.

Scope

This standard covers the testing of welds subjected to tensile stresses for resistance to cracking in aqueous environments containing a source of hydrogen charging. Carbon and low alloy steels and their matching welds are commonly tested for EAC resistance at room temperature where susceptibility is typically high. For other types of alloys, the correlation of EAC susceptibility with temperature is more complicated. For example, dissimilar welds of nickel alloy on carbon or low alloy steel have shown susceptibility at low, seabed temperatures (4 °C [39 °F]). Matching welds made on duplex stainless steels have shown similar susceptibility (DNV RP-F112).

This standard describes the reagents, test specimen (base material, weld, and specimen properties), equipment to use, and specifies the test procedure to follow. This standard describes one test method: Delayed Hydrogen Cracking Test (DHCT).[1,2]