Test Method to Evaluate the Effect of Reeling on Sour Service Performance of C-Mn Steel Linepipe and Girth Welds

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ABSTRACT

Installing linepipe by reeling can have advantages when compared to installation by S or J-lay methods, depending on the specific project requirements. In this work, a qualification method was developed to determine the effects of reeling on the sour service performance of line pipe and associated girth welds by using full-pipe-body reeling simulations, followed by either full-pipe four point bend, or small scale four point bend sulfide stress cracking tests. It was found that large scale SSC tests and the 250 HV hardness criteria were better discriminators of sour service performance of reeled line pipe than small scale four point bend tests per NACE MR0175/ISO 15156-2.

KEY WORDS: linepipe; reeling; SSC; HIC.

INTRODUCTION

Installing linepipe by reeling can have financial advantages when compared to installation by S or J-lay methods, depending on the specific project requirements. The cost benefits of reeling are a result of the following: 1) almost all of the welding, inspection and field joint coating are conducted on-shore, and off critical path, 2) there is minimal in-field vessel time, which 3) reduces the risk of stopping installation operations due to weather. The primary disadvantage of reeling is that the pipe experiences significantly more mechanical deformation than installation by S or J-lay. This deformation occurs when the linepipe is spooled on, and off the reel. The effects of this mechanical deformation prior to the exposure to sour environments needs to be adequately considered during qualification testing.

Hardness is a mechanical measurement that has been correlated to sulfide stress cracking (SSC) resistance (NACE MR0175/ISO 15156-2:2003(E), and EFC 16, 2002a). C-Mn steel line pipe with a Rockwell Hardness HRC less than 22 and Vickers Hardness (HV) less than 250 in the weld area is generally considered suitable for sour service. (DNV OS-F101, 2007a, API 5L, 2007a). It is unknown whether this hardness criterion also applies to plastically deformed materials.

A review of the literature has shown that excessively cold worked materials can have higher susceptibility to SSC (Sourmail, 2006). Industry standards also recognize that plastic strain can have a detrimental effect on mechanical properties, to include SSC resistance. Additional mechanical testing is required for any pipeline that will be deformed greater than 1%, but less than 5% for any given straining cycle, or when the accumulated nominal plastic strain is greater than 2% (DNV OS-F101 (2007)b). It is also recommended that any pipeline deformed greater than 5% in a single event undergo a thermal stress relief heat treatment to restore its SSC resistance (EFC 16, 2002b). Reeling imposes accumulated strains that are much greater than 2%, but less than 5% in any single event.

Previous work has examined the effect of simulating reeling by deforming small scale tensile specimens sectioned from C-Mn steel linepipe on Rockwell and Vickers Hardness and SSC susceptibility (Shenton 2005). However, this approach has yet to show that straining small scale specimens accurately represents the plastic deformation experienced during reeling a full pipe body. For example, residual stresses of the linepipe girth welds may not be accurately represented when small scale specimens are strained. Other industrial research examining the strain effect on pipe performance has indicated the shortcomings of small scale specimens versus large or full scale specimens. In this context the effects of straining full scale linepipe strings using a simulated reeling apparatus that subjected the entire pipe and girth welds to a representative stress-strain history followed by SSC testing of the full pipe body outlines another difference to small scale testing, i.e. one sided exposure versus fully immersed testing. The results of such testing affect the SSC susceptibility assessment of C-Mn steel linepipe and girth welds. Additionally, the method used to pre-strain the pipe may affect the SSC test result.

During reeling, the strain history is not uniform around the circumference of the pipe. When reeling onto the spooling hub, the outer most radius of the pipe (farthest from the hub) is in tension, while the other where the stresses are reversed (e.g. C-T vs. T-C). During reeling the imposed strain associated with the pipeline coming onto/off of the reel differs from that imposed on the pipe when it is straightened/tensioned. The effects of strain history on SSC susceptibility need to be evaluated to properly qualify reeled line