Effect of Reeling Strain on Sulfide Stress Cracking Resistance of X65 Linepipe and Girth Welds

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ABSTRACT
The installation of offshore pipelines using the reel-lay method has cost and schedule advantages over conventional S-lay and J-lay methods. For offshore pipelines that operate in a sour environment, the suitability of reel-lay installation is not as well established. When C-Mn steels are subjected to reeling they can experience a reduction in ductility and toughness as a result of cyclic plastic strain. Previously, a qualification method was developed to assess the effects of reeling on the sour service performance of line pipe and associated girth welds. In the current study, this qualification method has been used to evaluate the effect of reeling strain on the sulfide stress cracking resistance of X65 linepipe and girth welds having hardness less than the NACE sour-service hardness limit of 250 HV10 in the as-welded condition.

KEY WORDS: linepipe; reeling strain; SSC.

INTRODUCTION
The installation of offshore pipelines using the reel-lay method has cost and schedule advantages over conventional S-lay and J-lay methods, as the majority of the pipeline can be fabricated at an onshore spool base well ahead of the critical offshore phase of the pipeline installation project. When C-Mn steels are subjected to reeling they can experience a reduction in ductility and toughness as a result of cyclic plastic strain. This is generally not a concern for pipelines that operate in sweet service, as mechanical properties in the strained & aged condition are normally acceptable for this environment. For offshore pipelines that operate in a severely sour environment, the suitability of reel-lay installation is not as well established.

In work reported previously (Noecker et al., 2009), a qualification method was developed to evaluate 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 scale four point bend, or small scale four point bend sulfide stress cracking tests. It was found that full scale sulfide stress cracking (SSC) tests were a better discriminator of sour service performance of reeled line pipe than small scale four point bend tests per NACE MR0175/ISO 15156-2 (2003), in welds that exceeded the NACE sour-service hardness limit of 250 HV10. In the current study, the same qualification method has been used to evaluate the effect of reeling strain on the sulfide stress cracking resistance of X65 linepipe and girth welds having hardness less than 250 HV10 in the as-welded condition.

C-Mn steel linepipe installed using conventional lay methods is generally considered suitable for sour service provided maximum measured hardness of the welds and parent material does not exceed Rockwell 22 HRC or Vickers 250 HV10 (DNV OS-F101, 2007a; API 5L, 2007). It is unclear whether this acceptance criterion is equally applicable to reeled linepipe, which undergoes considerable plastic strain during installation. There is evidence in the literature indicating that heavily cold worked materials can have higher susceptibility to SSC (Sourmail, 2006).

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 that adjacent to the hub is placed in compression. This stress state reverses when the linepipe is reeled off the spool, which results in two different strain histories. Also, the 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 pipe for sour service. DNV OS-F101 (2007) recognizes that reeling strain can affect mechanical properties, but only requires additional mechanical tests to be performed using specimens with a strain history that ends in tension. The current study evaluates both conditions.

The main objective of this study was to assess the SSC resistance of reeled X65 carbon steel linepipe using large and small scale test specimens subjected to simulated reeling strains.