Offshore In-Service Resistance of Double Joints
Under Strain-Based Conditions

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Tenaris, Centro Sviluppo Materiali, and Saipem launched a cooperative program aimed at evaluating the in-service flaw tolerability of girth welded seamless pipes for offshore applications. Full-scale testing was conducted considering severe biaxial loading scenarios replicating actual offshore in-service conditions. Tearing by an occasional high axial strain was taken into account in order to consider suitability for strain-based conditions. Different notch sizes and sampling positions were also taken into account, thus improving the experimental database, which may assist the designer to evaluate the pipeline residual resistance when it is subjected to specific installation and in-service loading conditions.

NOMENCLATURE

\( a_0 \) Initial notch depth
CT Compact tension
CTOD Crack tip opening displacement
EDM Electrical discharge machining
FL Fusion line
FST Full-scale test
HAZ Heat-affected zone
ID Internal diameter
LVDT Linear variable differential transducers
OD Outer diameter
\( R_m \) Tensile resistance
\( R_{0.5\%} \) Yield strength
SAW Submerged arc welding
SBD Strain-based design
SEN Single edge notch bending
SENT Single edge notch tensile
SMYS Specified minimum yield strength
STT Surface tension transfer
WCL Weld center line
WT Pipe wall thickness
Y/T Yield-to-tensile strength ratio
\( \Delta a_{\text{measured}} \) Measured crack growth

INTRODUCTION

Girth welded seamless line pipes for offshore applications may undergo high plastic deformation during their whole life and be subjected to cyclic loading that may lead to unstable fracture occurrence. In general, different loading conditions may be envisaged, associated with internal pressure, cyclic loads occurring during line shutdown, and possible high occasional strains (e.g., due to ground movement).

A strain-based approach is mandatory for the correct evaluation of weld flaw tolerability in the design, installation, and operation phases. Once the possible loading conditions have been identified, the evaluation of material behavior is necessary through tensile and toughness testing (both involving standard and nonconventional tests). The real girth weld linepipe behavior can be evaluated by full-scale testing as well as numerical finite element (FE) analyses and defect assessment procedures, when applicable.

In this regard, Tenaris, Centro Sviluppo Materiali (CSM), and Saipem launched a cooperative program through different projects aimed at evaluating the in-service flaw tolerability of girth welded seamless pipes for offshore applications. First, a joint industry project (JIP), named “Heavy-Wall SEVere ENVironment” (HWSEVEN), was conducted to study heavy-wall offshore pipelines under severe loading scenarios (Di Vito et al., 2010). Both numerical and experimental activities performed in the framework of the HWSEVEN project led to relevant results that have been applied in subsequent strain-based design (SBD)-related projects. Although in HWSEVEN the interest was focused on the ratcheting of high-walled pipes (53 mm pipe wall thickness (WT)), the next activity focused on the performance of seamless double joints in terms of weld defect tolerability. To this purpose, linepipe geometry of 296.5 mm outer diameter (OD) \( \times 21.2 \) mm WT was considered. Three full-scale tests (FSTs) were executed on flawed girth welded specimens, with notches artificially introduced by electrical discharge machining (EDM), in order to evaluate their tolerability.