An Operator Experience with Reel Lay of an LSAW Linepipe with Suspect Local Brittle Zones in the Seam Weld and Mitigation Measures

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ABSTRACT
A recent subsea pipeline project required reel lay of a medium diameter (OD/WT~20) longitudinal seam welded pipeline fabricated by the UOE process and welded by the LSAW process. Local brittle zones are an inherent feature of LSAW welding process associated with a complex mix of the chemistry, metallurgy and welding parameters. CTOD testing indicated suspect local brittle zones as witnessed by large scatter in CTOD data and sporadic very low measured CTOD values for samples notched into the HAZ. This paper describes work undertaken to provide technical assurance on the integrity of the linepipe subject to large plastic strains during reeling, installation fatigue and service conditions. It is concluded that reel lay of an LSAW linepipe with sporadic low CTOD values can be accepted on a case by case basis driven by service requirement for the pipeline.

Industry guidance is required for qualifying the LSAW seam welded linepipe in the presence of local brittle zones and for conducting laboratory small scale strain-aged testing on LSAW seam weld for material characterization purposes.

KEY WORDS: Reel lay; LSAW; Local Brittle Zones; LBZ; Seam weld; CTOD; strain-aged testing;

NOMENCLATURE
AWT … All Weld Tensile Sample
CTOD … Crack Tip Opening Displacement
ECA … Engineering Criticality Assessment
HAZ … Heat Affected Zone
HOC … Hold Down Clamp on the installation vessel
LSAW … Longitudinal Submerged Arc Welding
MPQ … Mill Procedure Qualification
NDE … Non Destructive Examination
R_{0.5} … Engineering Yield Strength at 0.5% Total Strain
R_{m} … Engineering Tensile Strength (UTS)
SENB … Single Edge Notched in Bending
STDDEV … Standard Deviation
TOFD … Time of Flight Diffraction

INTRODUCTION
A subsea pipeline project required use of an LSAW seam welded API 5L PSL2 X65 grade linepipe of a medium diameter (OD/WT~20) on an export line with reel lay as the preferred installation method. Industry experience of installation of an LSAW linepipe by reel lay method is sparse and typically restricted to clad or lined pipe. Majority of industry guidance is aimed at defining tolerable flaws for the girth welds through procedures such as DNV OS F101: Appendix A (DNV, 2013) and DNV RP F108 (DNV, 2006) and similar. Very little information and industry guidance is available on assuring the integrity of the seam weld itself following the reel lay process and subsequent pipeline service loads. The need is further exacerbated by the sporadic low CTOD values typically measured in material qualifications on LSAW seam weld.

The LSAW welding process is more prone to formation of LBZ due to larger heat input and associated metallurgical changes in the weld such as incomplete phase transformation of reheated HAZ and formation of martensitic-austenitic islands.

Reel lay induces repeated reverse plastic straining of the linepipe and of the longitudinal seam weld during installation and subjects the seam weld to the fatigue during installation. In-service pressure – temperature cycling and any free span VIV or crossings induce further fatigue loads on the seam weld which is concurrently exposed to the transported fluids environment.

In the present work the LSAW linepipe application was for a repair of an export pipeline transporting non-sour fluids. The service conditions were relatively benign with a low pressure and a max operating temperature of 52 degree C with no concerns on large strain in-service events. Lowest design temperature was set at -10 degree C. The design life was 22 years.

Within Royal Dutch Shell group installation of an LSAW linepipe by reel lay method is relatively uncommon. Attempts in the GoM in early 2000’s exposed fit-up difficulties with the girth weld due to fabrication tolerances of the seam weld. Other experiences were generally not adverse to this approach.