EWI Strategic Technology Committee
Oil & Gas

Research for 2019

Tom McGaughy
Senior Technical Advisor

The Strategic Technology Committee for Oil & Gas (STC) was established by EWI in 2013. It provides a platform for oil & gas operating companies, steel suppliers, welding equipment and consumable manufacturers, engineering and construction companies, and other stakeholders to collaborate in identifying gaps and needs in materials joining and allied technologies relevant to the energy industry, and then establish and oversee technology development programs to address those needs. The objective of these programs is to enhance the safety, integrity and reliability of critical infrastructure used in the exploration, production and delivery of energy products to markets worldwide .

STC-funded projects for 2019 are briefly discussed herein.

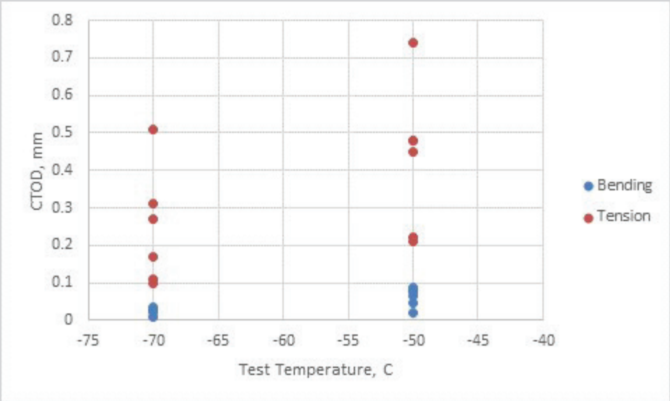

Figure 1. CTOD results versus testing temperature

Managing Brittle Fracture in Subsea Hardware, Flow Lines, and Risers

Subsea equipment in the form of steel forgings and pipe is often used in conditions where the lowest design temperature (LDT) is below the lowest anticipated service temperature (LAST) due to transients such as blowdown, which can lower the metal temperature due to the Joule-Thomson effect. Blowdown events can happen multiple times during the operational life of a subsea pipeline system. When the steel is qualified with toughness tests at LAST, the safety factor against brittle fracture will be reduced at the LDT, all other things being equal, due to the ductile to brittle transition of steels.

Phase 3 of this project, to be completed in 2019, will focus on establishing guidance for incorporating constraint effects under blowdown conditions to improve accuracy of fitness-for-service or engineering critical assessments. This work builds upon earlier experimental phases that characterized constraint effects on X70 base pipe in 2016, and characterization of weld and HAZ properties in 2017 and 2018. The characterization included chemical composition, tensile properties, Charpy transition curves, crack tip opening displacement (CTOD) fracture toughness, and microstructure assessment of the weld region and the fusion-line notch position. The test plan examined brittle fracture resistance at temperatures slightly below the lowest design temperatures at -70°C and -50°C for both single-edge notch bending (SENB) and single-edge notch tension (SENT) CTOD tests. Testing results (Figure 1) showed that at both these temperatures, the shift to higher CTOD at lower constraint was reliable over the 24 tests, even accounting for the variability expected when testing weld metal from multi-pass welds.

The outcome of the project will provide guidance on the best approach for characterizing material properties and qualifying materials to ensure integrity under unexpected blowdown scenarios for subsea equipment.

Factors Influencing Copper Contamination in Girth Welds

Mechanized pipeline girth welds can suffer copper contamination under certain conditions, with the source of copper originating from copper line-up clamps and/or copper contact tips on the welding torch. Depending on the amount of copper and its location within the weld deposit, cracking can occur due to liquid metal embrittlement or as a result of increased localized hardening associated with copper deposits. These occurrences can be particularly detrimental to weld integrity when the pipeline is operating in sour service conditions.

This project began in 2018 and will continue through 2019. The objectives are to (1) increase understanding of the amount of entrained copper necessary to degrade weld integrity and (2) carryout initial feasibility trials on detecting copper contamination using automated methods employed during welding. Figure 2 shows the layout for welding over copper blocks. Weld integrity will be determined via mechanical property and NACE sour service tests. Work completed to date shows promise for the development of automated methods for detecting entrained copper in the weld pool beyond typical background levels found with copper coated welding wires. Further work on detection resolution will continue in 2019 along with quantification of amounts of copper that degrades mechanical properties and sour service performance.

The outcome will be improved awareness of conditions leading to copper contamination and the identification of instrumentation that can be integrated into mechanized welding equipment to continuously monitor and confirm when critical levels of copper have been entrained into a girth weld in near real-time.

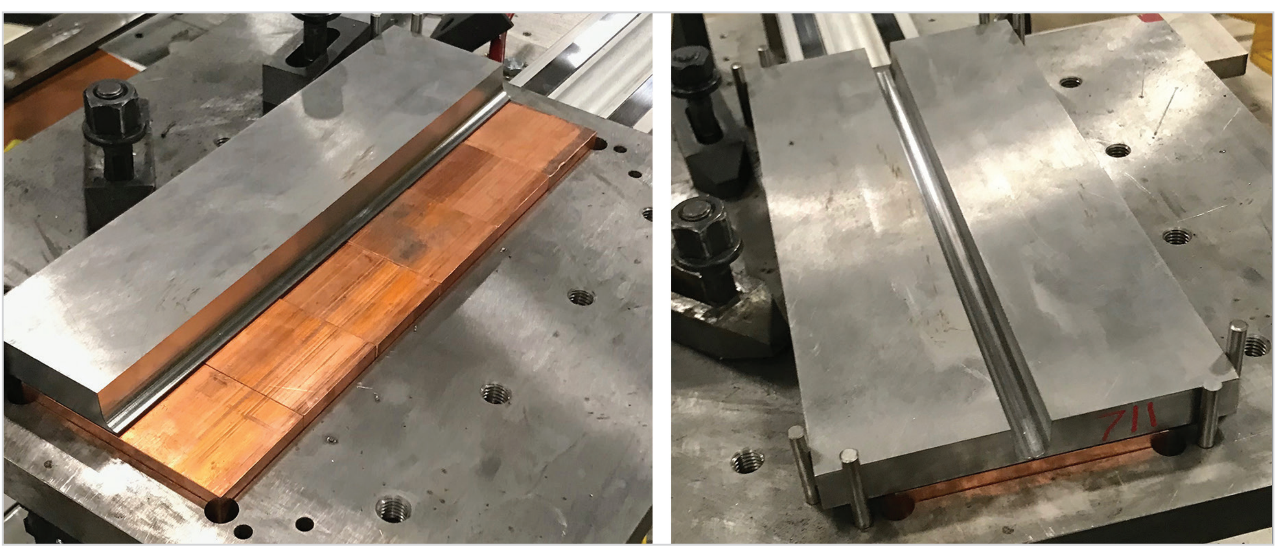

Figure 2. Setup of test plates for welding over copper blocks

Weldability of Manganese Line Pipe Steel for Sour Service

Pipelines operating in sour service conditions have more stringent requirements on pipe steel chemical composition and on weld and heat affected zone (HAZ) hardness limits to reduce hydrogen assisted cracking (HAC) sensitivity. A modified pipe steel has been developed to reduce HAC by significantly lowering manganese content in API 5L X60 and X65 grade steels. The reduced manganese level results in fewer manganese-sulfide stringers in the steel, which are hydrogen traps that increase HAC. In addition, the low manganese content may allow higher levels of sulfur in the steel, opening the possibility for older continuous cast steel mills to produce sour service grade pipe, and thus increasing the number of mills that can source high integrity sour service line pipe.

This project, which began in 2018 and will continue through 2019, is the first independent weldability evaluation of the low manganese steel. The seam and girth welds and the associated HAZs are undergoing testing to quantify tensile, Charpy impact and CTOD toughness, and hardness and sour service cracking properties for comparison with conventional X60 and X65 pipe steels. Figure 3 illustrates the hardness correlation around a girth weld in the low manganese pipe.

Detailed microstructural characterization of the weld and HAZ regions will be included. STC members will receive a detailed spreadsheet comparing low manganese and conventional X60/X65 pipe material properties.

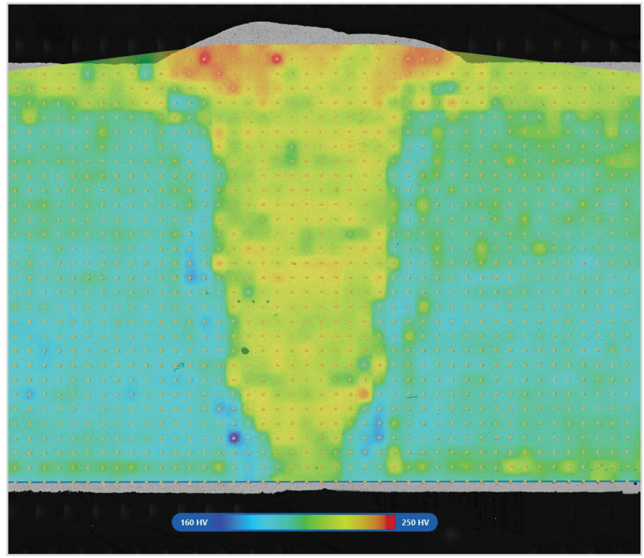

Figure 3. Hardness Profile Map for Mechanized Girth Weld in Low Mn Pipe

The outcome of this effort will enhance pipeline design and weld fabrication practices for using this unique line pipe steel and offer pipeline operators an alternative pipe material for use in sour service environments.

To learn more about the activities and projects of the STC, contact **tmcgaughy@ewi.org** or visit **the STC web page**.

Tom McGaughy *is Senior Technology Advisor for structural integrity-related and modeling technologies, contributing to a variety of projects and managing EWI's relationships within the oil and gas and power industries. He also manages the EWI Oil & Gas Strategic Technology Committee (STC), a consortium focused on developing pre-competitive technologies for industry.*