Measuring the Effect of Cathodic Protection on the Performance of Thermally Sprayed Aluminium Coatings at Elevated Temperature

PUBLISHABLE SUMMARY

24323

Background

Thermally sprayed aluminium (TSA) coatings are increasingly used to mitigate the corrosion on subsea pipelines and structures. Other than the results of work published in the early 1990s relating to the effect of various levels of cathodic protection (CP) at ambient North Atlantic seawater temperatures, there are limited published data covering the interaction of TSA and CP when applied to hot and thermally-cycled risers and hydrocarbon transportation pipelines.

To address the issues highlighted above, this project will use quantitative methods to measure coating current demand under selected CP values and to measure potential and corrosion rate at E_{corr} during long-term testing at elevated temperature and during thermal cycling. With many new fields involving the installation of increasingly difficult-to-maintain and remote deep-water facilities and extraction of hotter hydrocarbons, generation of such data will provide oil producers and installation companies with increased confidence in the long-term reliability of TSA coatings in subsea service. The implication of project results for cathodic protection design codes and standards will be reported.

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Objectives

The main objective of this project is to generate data demonstrating the compatibility of TSA with cathodic protection applied across a range of representative potentials. This will include measurement of the effects of selected environmental conditions (elevated temperature and thermal cycling) and variation in coating specification (composition and use of sealants).

Project Progress

- The information gathered so far indicates the effectiveness of TSA in protecting steel at elevated temperatures without CP even when damaged.
- TSA shows healing of the damaged region by the deposition of calcareous matter in seawater even at elevated temperatures.
- The CP limit imposed by the commonly used standards can be detrimental for the TSA coating system.
- Designing a CP system for hot risers coated with TSA should include studies to assess the effect of the applied potential on the coating system.

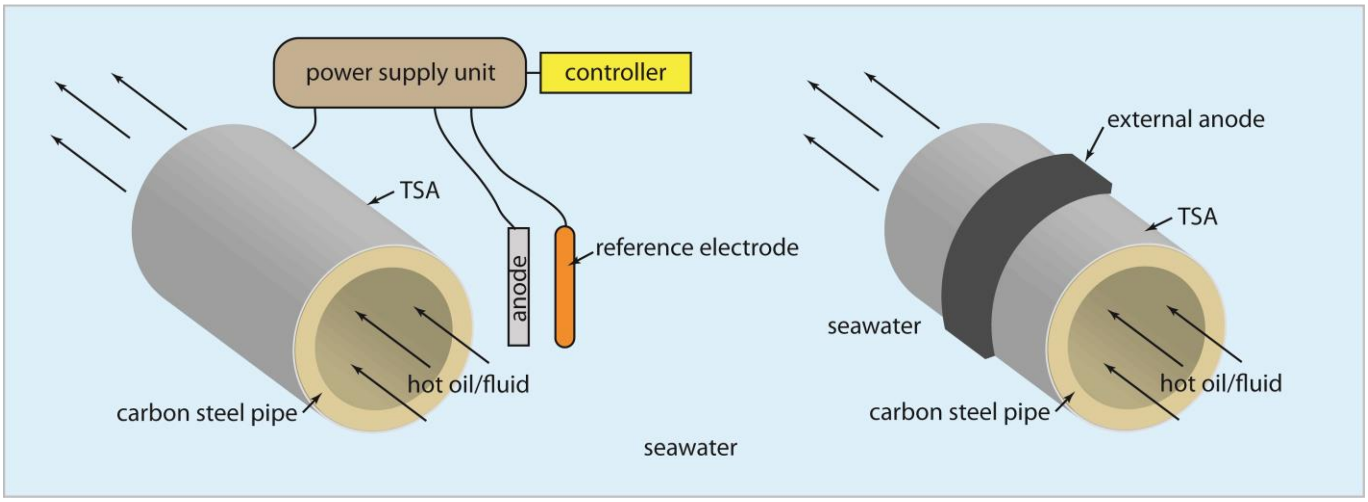
Benefits

- Generation of environment-specific cathodic protection design data, which will provide oil producers and installation companies with increased confidence in the long-term reliability of TSA coatings in inaccessible, deep-water service.
- Extended operating life of facilities in remote locations with reduced maintenance costs.
- The opportunity to reduce anode mass on subsea structures by up to 80% (thus reducing structural mass and cost).

Participants

The Sponsor Group currently comprises:

- ExxonMobil Development Company
- Total E&P France
- BG Group



Scope of Work

The following work packages are being undertaken:

WP1 Preliminary Evaluation of the Effect of Temperature on the Behaviour of TSA Coating Under Different Applied Potentials.

Preliminary work was undertaken to confirm the detail of the test conditions proposed for WP2 (Elevated Temperature) and WP3 (Thermal Cycling) based on representative environmental service conditions provided by Sponsors and laboratory testing comprising:

- Uncoupled response (free corrosion potential / E_{corr}) of two unsealed TSA alloy compositions (on an inert substrate) up to 90ºC.
- Coupled response of unsealed TSA (on an inert substrate) with applied potentials at 30°C, 60°C and 90°C.
- TSA-coated steel with holiday areas up to 20%.

These preliminary tests were conducted in synthetic seawater conforming to ASTM D1141 at atmospheric pressure with potential and current recorded throughout a minimum test period of three months

WP2 Interaction of TSA with Cathodic Protection at Constant Elevated Temperature

A detailed study is planned to simulate the interaction of TSA with cathodic protection in a representative service environment, comprising:

- TSA-coated test coupons mounted in the wall of tower containing hot oil at 130°C, immersed in chilled artificial seawater at 10°C.
- TSA coating skin temperatures of unburied and buried test coupons.
- Cathodic protection levels: E_{corr} and 1 CP level by impressed current.
- Potential and current recorded.
- TSA coating composition down-selected from WP1.
- Sealed and unsealed TSA.
- Coatings with holidays.
- Test conducted at atmospheric pressure.
- SEM examination of coating microstructure and EDX element analysis of corrosion products following exposure.

WP3 Interaction of TSA with Cathodic Protection Subject to Thermal Cycling

A detailed study will be undertaken to simulate the interaction of TSA with cathodic protection subject to representative thermal cycling service conditions, comprising:

- Half buried, vertical TSA-coated pipes containing oil cycled from 130°C to 10°C, immersed in chilled artificial seawater at 10°C.
- Cathodic protection level to be determined from WP1 and WP2.
- Impressed potential by Pt electrodes and selected tests including AlZnIn anodes.
- Potential and current recorded.
- TSA coating composition down-selected from WP1.
- Sealed and unsealed TSA.
- Coatings with multiple holidays.
- Test conducted at atmospheric pressure.
- Test duration of up to 12 months.

Performance of coatings and anodes will be characterised as follows:

- Test coupon surface examined post-exposure.
- SEM examination of coating microstructure and EDX element analysis of corrosion products following exposure.

WP4 Implication of Test Results for Cathodic Protection Design

Detailed interpretation of WP1-3 test results will be undertaken with regard to their implication for cathodic protection design codes and standards including:

- Effect of increasing temperature on TSA corrosion rate and electrochemical potential.
- Current density requirements and potential to achieve adequate CP design under typical service conditions compared with design values recommended in international CP design codes.
- Effect of cathodic polarisation levels on TSA coating corrosion.
- Effect of sealants on TSA corrosion rate and electrochemical potential.
- Behaviour of sacrificial anodes in the presence of TSA.
- Effect of increasing temperature on anode corrosion rate and electrochemical potential.
- TSA corrosion mechanism based on corrosion products and calcareous deposits on coatings and holidays

Price and Duration

The project has a duration of two years and a budget of £210,000. Currently there are three Sponsors each making a contribution of £70,000. The final scope of the project is dependent on the number of Sponsors.

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

http://www.twi-global.com/services/research-and-consultancy/joint-industry-projects/

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