



POLYMER LINING TECHNOLOGY
PIPELINE AND RISER SYSTEMS

Qualification of an innovative electrofusion welded connector for polymer lined subsea pipelines

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AGENDA

- Industry challenge and our solution
- Introduction to LinerBridge®
- Construction and installation
- Qualification of new technology
- Critical qualification activities
- First deployment and further developments
- Summary

The industry challenge

- **51%** of all pipeline failures are a result of internal corrosion
- **7 years** is typical life expectancy of an unlined carbon steel water injection pipeline*
- Traditional corrosion allowances now driving pipeline wall thickness up to 2 inches.



6 o'clock groove corrosion

* Failure of water injection lines Joint Industry Project, by AEA Technology, July 1997:

- *23 water injection lines included in study, only one had survived 15 years*
- *Eight flowlines had already failed, with average corrosion rate of 1.7mm/year*

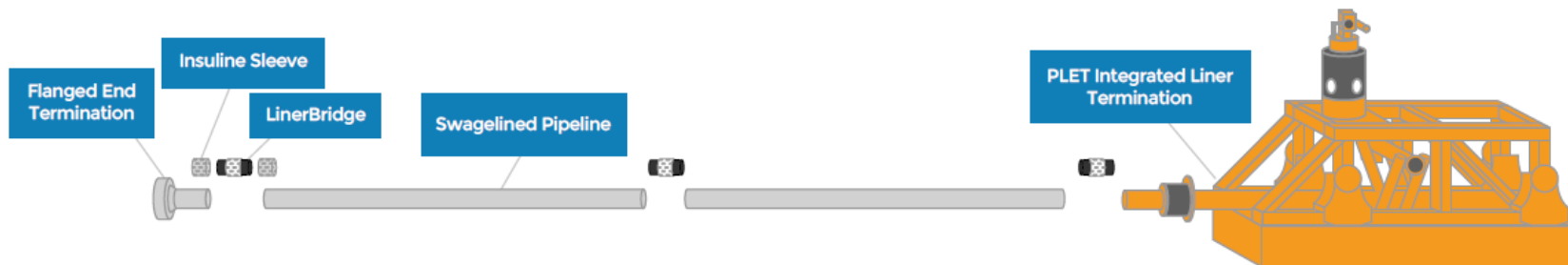
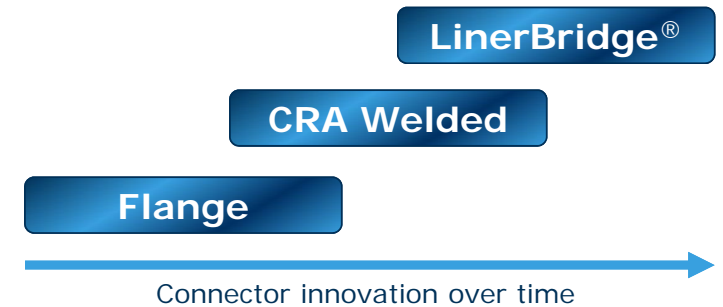
Our solution – the Integrated Liner System

- **Polymer lining** - to provide a 50 year internal corrosion barrier
- **Connectors** - LinerBridge[®] to join pipeline stalks together to provide a continuous end to end polymer corrosion barrier
- **InsuLine[™] sleeves** - to provide heat protection should high temperature field joint coatings be specified
- **End terminations** - Flanged or PLET's installed onshore or offshore using LinerBridge[®]



Introduction to LinerBridge®

- Removes Corrosion Resistant Alloys from subsea pipeline infrastructure
- Reduces pipeline fabrication complexity, cost and schedule
- Facilitates installation of pre-fabricated end terminations
- Enables polymer lining for S-Lay and J-Lay

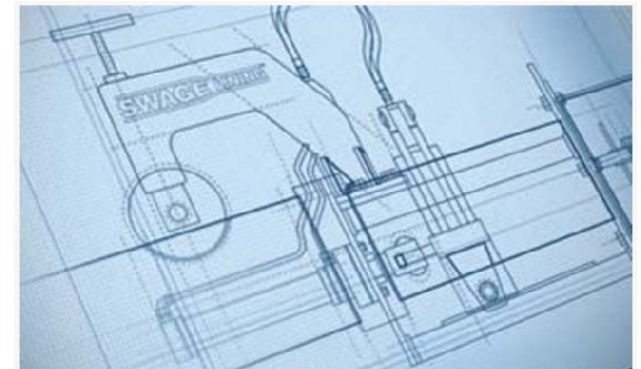


SWAGELINING™



Qualification of new technology

- Det Norske Veritas (DNV GL) Recommended Practice A-203
- Systematic, risk based approach to qualification of new technology
- Sound engineering practices to ensure product is suitable for intended use
- Focus on the novel aspects of the technology
- Technology Readiness Level (TRL) 5



Critical qualification activities

Critical product functions and test activities included:

- Installation environment
- Offshore installation – ability to be reeled
- Withstand pipeline operating conditions
- Design life considerations
- Carbon steel welding process



Installation environment

Product performance specification

Installation can be completed between the temperatures of 5°C and 40°C

Test activities

- Installations completed at each boundary condition
- Installations completed on 8" and 16" connectors
- Connectors destructively tested



Offshore installation - ability to be reeled

Product performance specification

Connector must maintain its integrity during the offshore installation process



Test activities

- Simulated Reeling Trials (SRT) – 7.5m former
- Installations completed on 10" and 16" connectors
- Post SRT, test spools hydrostatically tested
- Connectors destructively tested

Pipeline operating conditions

Product performance specification

Connector must maintain its integrity at operating pressures and temperatures

Test activities

- Hydrostatic testing to 380bar(g)
- High temperature cyclic pressure testing
- Collapse testing
- Connectors destructively tested

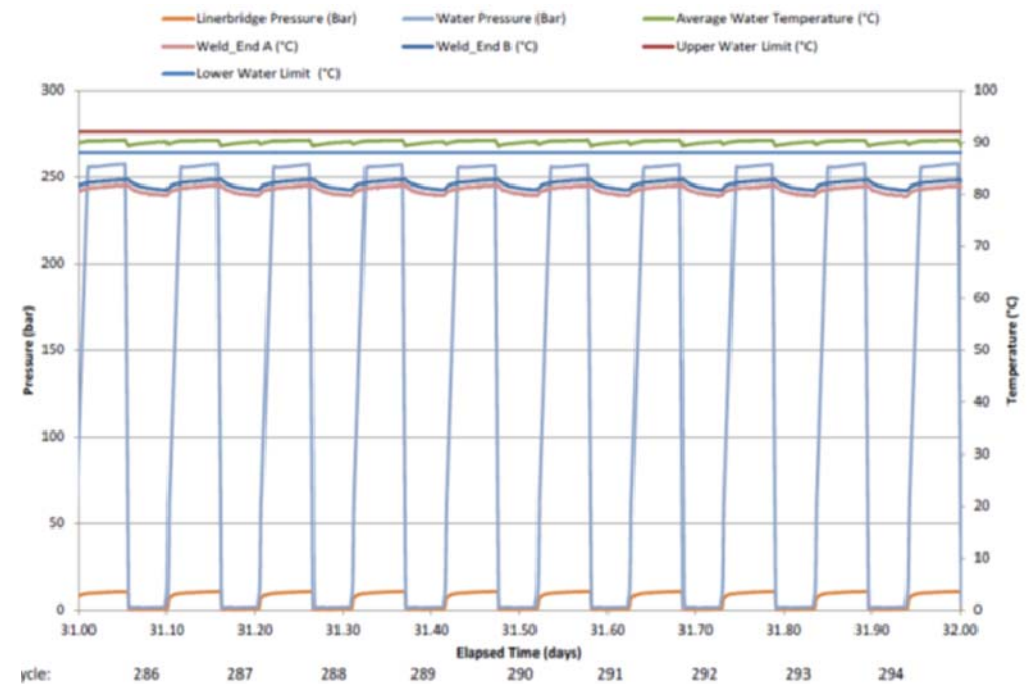


Figure 5: Sample of Daily Plotted Temperature and Pressure Data

Design life considerations

Product performance specification

Polymer liner system materials provide appropriate mechanical properties at end of life.

Test activities

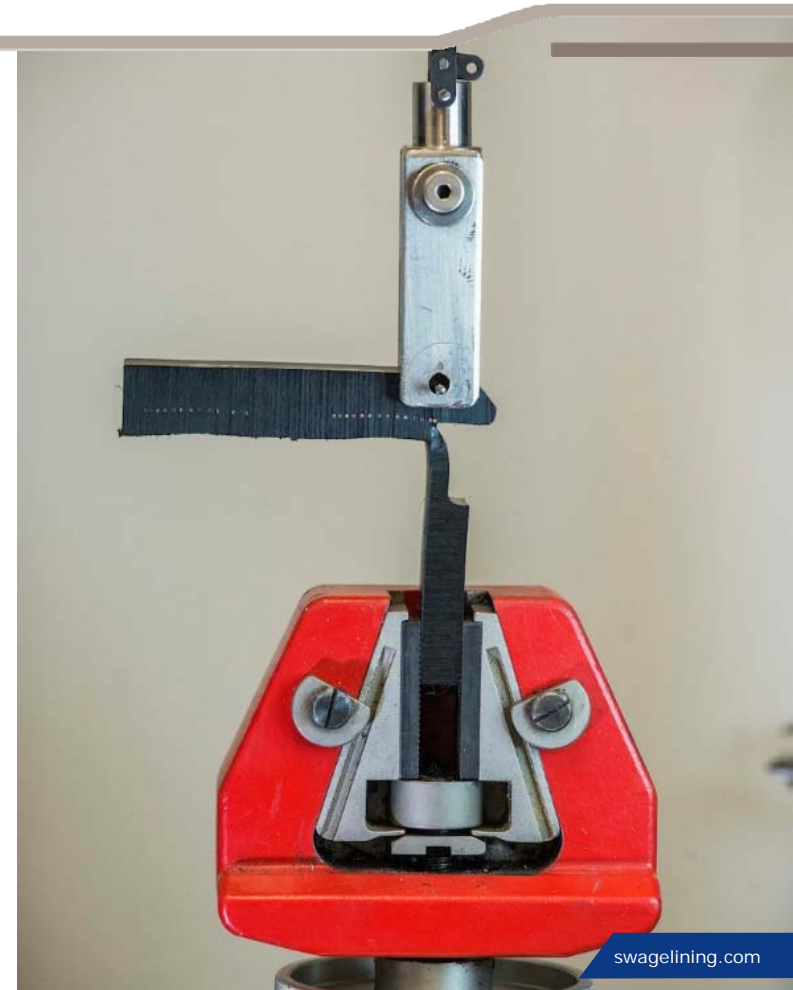
Virgin materials testing Ultrasonic inspection

Accelerated age testing Post aged - materials testing

Temperature cycling

$$1/t_f = \sum_{i=1}^{i=n} \left(\left(\frac{t_i}{t_{tot}} \right) / t_{fi} (T_i, s_i) \right)$$

Miner's Rule



Carbon steel welding

Product performance specification

Connector facilitates the use of manual carbon steel welding processes.

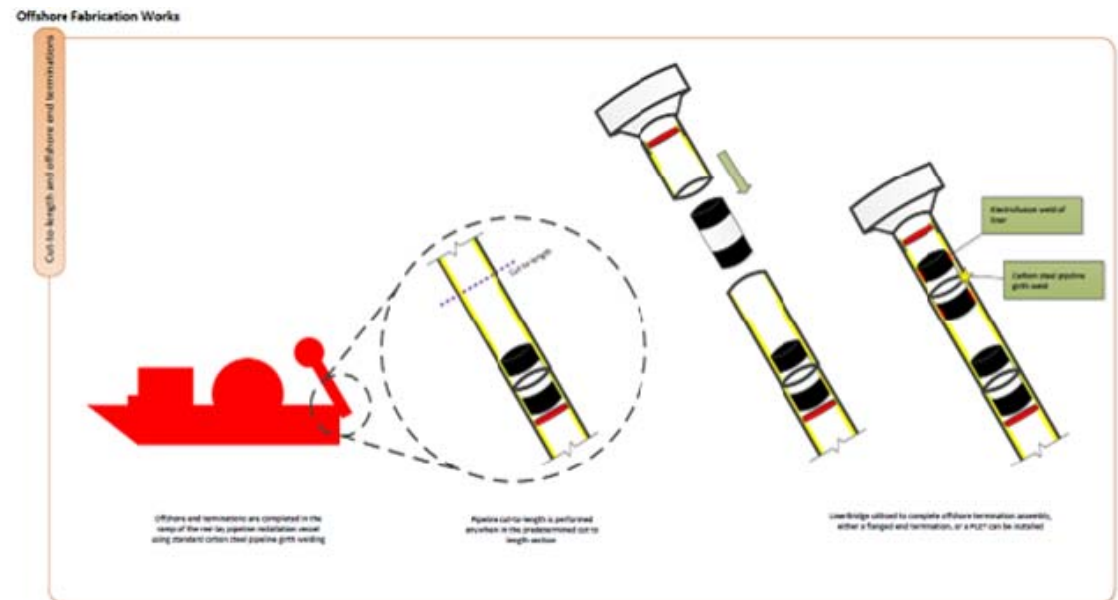


Test activities

- Thermocouple installation
- Temperature monitoring during carbon steel welding processes
- Full penetration repair
- Visual inspection of connector body

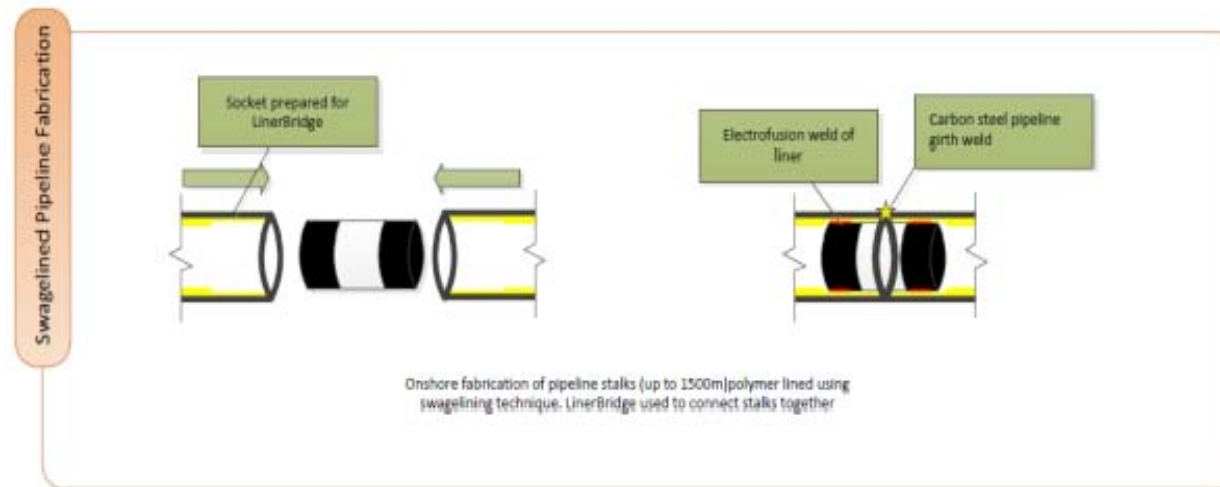
LinerBridge® – First deployment and further developments

- First use in a commercial project – Equinor Snorre
- DNV certificate amendment – increased operational pressure (445bar)
- DNV certificate amendment – LinerBridge® use for offshore cut to length operations
- LinerBridge® selected for use in two further 2019 projects



Summary

- LinerBridge® provides clear technical and commercial advantages
- Flangeless polymer connector suitable for the complete pipeline system
- Future connector developments
- Qualification of New Technology – DNV GL RP A203 (TRL 5)
- First commercial project commenced, others scheduled for 2019



THANK YOU



We look forward to discussing your needs
and exploring where we can best support you.

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