Case Study
Starling pipe-in-pipe project

Project Name: Starling
Client: Shell U.K. Limited
Location: North Sea

Scope of work
• 33km 12" (324mm) outside diameter seamless inner pipe
• 33km 20" (508mm) outside diameter welded outer pipe
• HFI welded outer pipe, 508mm outside diameter
• Integration of inner and outer pipe sections
• Injection of polyurethane foam
• Supply and fitting of zinc alloy anode pads
• External 3 layer polypropylene coating of outer pipes
• Weld preparation bevel on end of outer pipes
• Welding of circumferential backing rings
• Supply and fitting of water stop sealed bulkheads
• Manufacture and welding of steel half shells
“We engaged with linepipe suppliers very early in the Starling project to gain their input to the pipeline design, and ensure timely delivery in a tight market. Our relationship with Tata Steel was very positive and proactive throughout the project.”

Liam Naughton, Starling project manager, Shell
As a leading steel producer, Tata Steel capitalises on decades of experience, expert knowledge and global capabilities to deliver pipeline solutions for challenging and complex projects around the world.

We work in partnership with our customers to provide insulated pipeline systems which maintain flow assurance to maximise returns on field developments. These systems include multi-layer, polypropylene foam and aerogel hybrid systems to cover the full range of insulation levels required.

The use of pipe-in-pipe systems for the thermal insulation of pipelines is well established. Since 2004 Tata Steel has been the front-runner in delivering systems for pipe-in-pipe projects in the North Sea, including BP Rhum and Talisman Tweedsmuir. The Starling project was the first development in which Tata Steel was able to supply a complete, engineered solution to Shell U.K. Limited, who operates the field on behalf of Shell and Esso Exploration and Production UK Limited.

The Shell/EssO Starling field in the central North Sea is a significant gas condensate discovery. Central to the project was the installation of a 33km long 20”/12” carbon steel pipe-in-pipe system to tie back wells to the Shearwater platform. Tata Steel delivered a pipe-in-pipe solution for the project, supporting front-end engineering and design through to delivery, thereby taking on greater project risks and providing the benefits of reduced supply chain complexity.

Working in partnership with the customer, Tata Steel delivered a comprehensive project-managed portfolio of pipe-in-pipe design solutions including engineering, manufacturing, field jointing and supply services. The company assumed complete supply chain management for the Starling pipe-in-pipe project, incorporating the engineering, procurement, fabrication phases and testing: shoudering the responsibilities associated with such an all-encompassing scope of work.

In recognition of the successful completion of the project and Tata Steel’s commitment to safety, the project team was presented with an award from Shell U.K. Limited, celebrating the benefits of a fully integrated package and a close working relationship between supplier and operator.

Complete package supply
Tata Steel has a long-standing relationship with seamless pipe producer Vallourec & Mannesmann (V&M) and this resulted in significant benefits in creating an effective system for Starling. Through close co-operation, Tata Steel was able to manufacture outer pipes which matched exactly the inner pipe lengths. This made it easier to achieve optimal matching of pipe lengths to create finished joint sections.
The 12m outer sections of the carbon steel pipe-in-pipe, incorporating 2,800 joints, were made at the company’s 20” high frequency induction (HFI) welded pipe mill in Hartlepool, UK. The seamless carbon steel inner pipe was made by V&M and imported to the north of England. Measurements for the inner pipe were 324mm outside diameter with a wall thickness of 20.6mm, broadening to 22.2mm for the Shearwater approach. The outside diameter for the outer pipe was 508mm (20”) with a wall thickness of 12.7mm.

Once manufactured, the outer pipes were fitted with carbon steel anode pads ready for the installation of zinc alloy anodes. The pipes were then coated with polypropylene at the Tata Steel joint venture company, BSR Pipeline Services in Hartlepool. Next the pipes were batched and matched length-for-length and integrated to form complete pipe-in-pipe joints.

**Accuracy and excellence**

Ensuring complete accuracy in concentricity was essential, and the Starling system was proved to have excellent dimensional tolerances. The general requirement of concentricity of an outer pipe to an inner pipe is up to 2mm; the Starling system delivered a mean concentricity of 0.7mm. The tolerance of the stick-out of inner pipe at the end of each section was also crucial and had to be precise; this was set at a narrow range of -0 / +2mm (see diagram above).

The assembly of the joints was completed with a weld preparation bevel on the outer pipe and the welding of a circumferential backing ring. As such, the field joints for the Starling project were designed to fit together without the need for further assembly or remedial work enabling optimal pipelay at approximately 1km a day.

The pipe-in-pipe system was insulated with polyurethane foam to the density of 120kg/m with a thermal insulation of 0.035 W/m2K. With pipe-in-pipe, the ‘U’ value - the overall heat transfer co-efficient - is paramount. Referenced to the inner pipe bore the Starling project required 0.7 W/m2K. By comparison, wet insulations can withstand a heat loss of 3W/m2K or greater.

Tata Steel supplied its patented water stop sealed bulkheads to prevent water ingress in the event of a wet buckle during pipelay. These bulkheads were fitted into one in every 28 pipe assemblies. The company also manufactured full body tempered steel half shells, including cutting, machining and welding for completion of the field joints during offshore pipelay. The half shells were made to tight tolerances of less than 2mm spring when split, and the overall tolerance was less than 0.5mm on the lengths and remaining dimensions.

Six bulkhead assemblies were welded into the pipeline, one at each flanged end and four along the length of the pipeline, to distribute the thermal stress caused by the internal temperature and pressure of well production fluids. All welding on the assemblies was completed and tested by Tata Steel, with welds having to withstand tested temperatures of -45°C over the pipeline’s life.
At Tata Steel, we work together with our customers to meet their requirements, however challenging.

Weld qualification at such low temperatures while maintaining dimensional accuracy were anticipated challenges at the outset but these issues were successfully managed. Tata Steel enlisted welding specialists, Pipeline Technique Limited (PTL) to develop the project specific welding techniques for both the inner and outer pipe to bulkhead joints. After assessment of the exacting quality, strength and notch toughness criteria, PTL selected the Gas Tungsten Arc Welding (GTAW) process, matched with a 1% Nickel-alloyed consumable. A team of welders successfully qualified the Welding Procedure Specifications (WPS) at the PTL welding centre near Aberdeen, before moving to the Tata Steel plant to successfully complete the bulkhead assembly joints.

The non-destructive testing (NDT) of the WPS and production bulkhead welds included full volumetric inspection by radiography and ultrasonic testing. The destructive testing of the weld procedure samples was extensive and encompassed tensile tests, bends and macro-sectioning, plus an intensive investigation into the low temperature toughness properties by CTOD (crack tip opening displacement) and Charpy V-notch impact specimens.

**Integrated supplier**
From a customer’s perspective, working together with just one supplier with experience and understanding of all the technical challenges and potential risks in this field was a considerable benefit. The biggest challenge for Tata Steel was coordinating the supply of materials, and ensuring different aspects of the project integrated smoothly.

Tata Steel was brought into the project in the very early stages, supporting Shell on aspects such as the selection of the right pipe configuration, foam formulations and what thermal properties could be achieved. Budget information was also supplied to help Shell to assess the capital case supporting the project development.

Shell’s Starling project manager Liam Naughton said: “We engaged with linepipe suppliers very early in the Starling project to gain their input to the pipeline design, and ensure timely delivery in a tight market. Our relationship with Tata Steel was very positive and pro-active throughout the project. The pipe-in-pipe assembly went very smoothly at Hartlepool, with Tata Steel drawing from their previous experience to make continuous improvements to the safety and efficiency of the operation.”

Shell’s Starling subsea team leader Euan Sellar added: “The installation of the pipeline has been a successful operation reflecting the joint commitment of operator and supplier to overcome the onerous technical challenges of a complex project.”

**Multiple benefits**
The Starling system was designed specifically to cope with the particular stresses inherent with the S-lay method of pipelay. During this lay method the inner and outer pipe are required to be bonded together. This can cause difficulties aligning adjacent pipes for welding. The tight tolerances achieved by Tata Steel ensured that the required fit-up was achieved without the need for costly and time-consuming remedial work on the lay barge.

Operationally, the Starling pipe-in-pipe is designed to offer not only thermal protection but also increased resistance to lateral and upheaval buckling. This is achieved through bonding the PU foam and the intermediate steel bulkheads.

As part of the project, care was taken in assembly and qualification to ensure that the axial strength was maintained and delivered as part of the project requirements.

**Conclusion**
As the pressure increases to develop more and more marginal fields with high pressure, high temperature (HPHT) wells, and as new technologies develop, pipe-in-pipe will continue to grow in importance in the years ahead.

By working in partnership with customers at an early stage in the engineering process, Tata Steel can offer significant benefits and expertise to ensure that the optimal pipeline insulation system is developed, meeting the specific requirements of each challenging project.

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Euan Sellar, Starling subsea team leader, Shell