Figure 1. Cable application machine during stalk assembly.

HOT OFF THE PRESS

Brian Lynch, Project Manager, Technip, UK, and Michael Dicker, Special Projects Manager, Heat Trace Limited, UK, unveil the world's first subsea heat traced reeled pipeline design.

The world's first electrically trace heated reeled pipe-in-pipe (ETH-PiP) has been installed for Total E&P UK, within the Islay field of the North Sea. Heat Trace Limited (HTL), a leading manufacturer of heat tracing cables and systems, provided the heating cable system for Technip UK Ltd's ETH-PiP. This ground breaking project is the product of many years of development work by Technip, latterly in conjunction with Total, and serves as an efficient active heating solution for challenging field developments.

The Islay project consists of the natural depletion extraction of gas condensate from the Islay reservoir located in Block 3/15 of the northern North Sea, approximately 6 km northeast of the existing Forvie Manifold. It is this manifold to which the Islay pipeline will be connected. The full Islay project work scope covers installation of a 6 km ETH-PiP, control umbilical, subsea structures and seabed preparation, including detailed design, engineering and project management.

Following a joint development programme in 2009/10, Total identified the Islay project as a test bed for ETH technology and decided to include trace heating within the planned production pipeline. Initially, the presence of the ETH system within the pipeline is to operationally test the technology as well as provide a back-up to the primary hydrate mitigation strategy – methanol injection. However, there is potential for ETH to become the primary mitigation method should testing of the system prove successful. This would involve a potential permanent umbilical connection to an existing platform in the future. Following tender, Technip, well renowned for its commitment to step change technologies, was awarded the engineering, procurement, construction and installation contract (EPCI) for the Islay project, to be managed from its Aberdeen operating centre.

Design

An ETH-PiP is made up of a standard pipe-in-pipe (PiP) to which a set of electrical trace heating systems and optional fibre optic temperature monitoring systems have been added. This combines the passive thermal efficiency of a PiP with the operational efficiency of trace heating, which is optimised by the high performance aerogel insulation. The combination of these two efficient technologies has the potential to open the door for operators to develop fields with specific flow assurance challenges, with much lower power demands than required for alternate heating solutions. Technip, as well as HTL, is already working on developments to open up longer tie-backs using cables with much higher power capacity for future applications.

The design of the ETH-PiP for the Islay project was completed following a co-operative effort from many Technip entities throughout the global organisation, including: Technip UK Ltd, DUCO, Technip France, Genesis and OED – the Offshore Engineering Division – responsible for managing and delivering the early R&D/qualification effort on the project, as well as other technologies that are now established within the industry. Specific design challenges included detailed modelling of the thermal behaviour of the pipeline during operation of the heating system using computational fluid dynamics (CFD). Further to this, the behaviour of the cables during reeling, as well as the behaviour of the pipeline itself, had to be considered. Although reeling of pipelines is well understood in the industry, the addition of reelable PiP bulkheads made this a special case requiring detailed finite element analysis and full scale bending trials. Such reelable components are yet another innovation required by the project to facilitate a single trip lay and fixed length pipeline, minimising unnecessary offshore operations, such as cable splicing and super duplex welding/half shells, which can be delayed by unfavourable weather conditions.

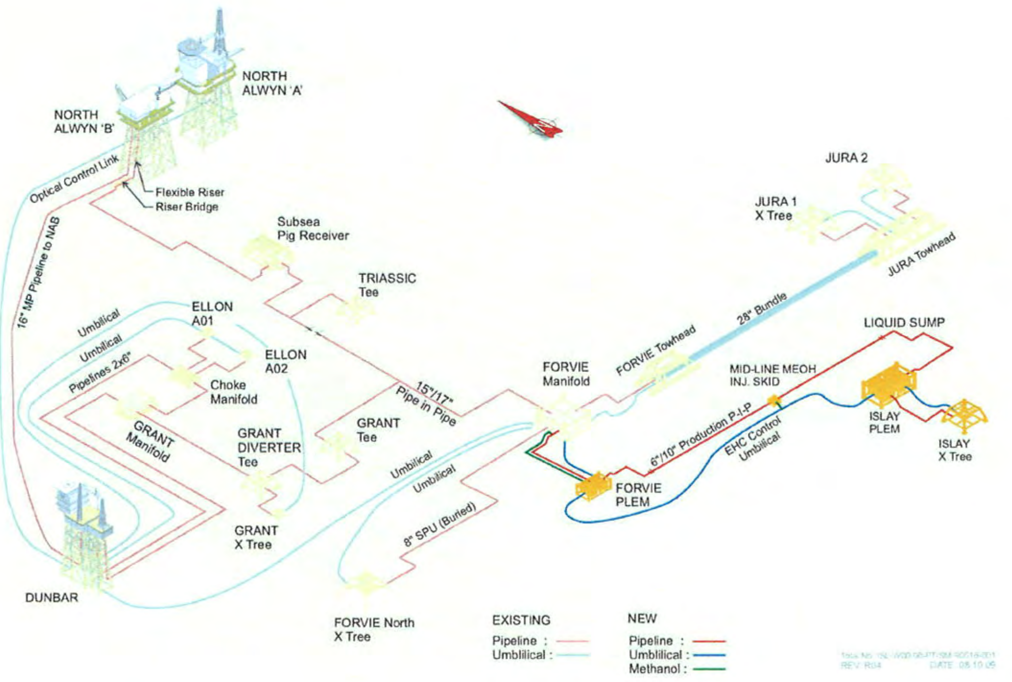

Figure 2. The Islay field.

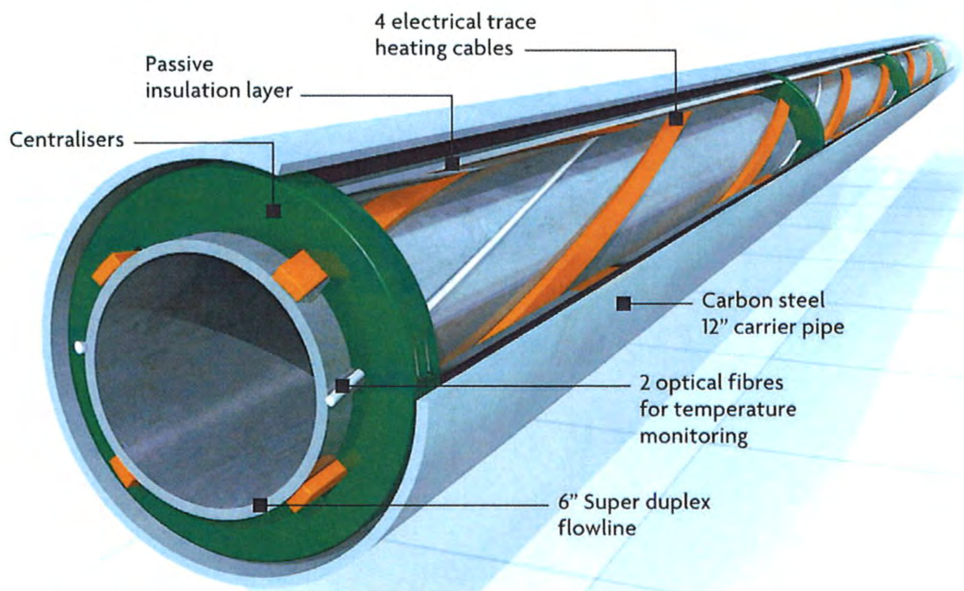

Figure 3. Typical ETH-PiP.

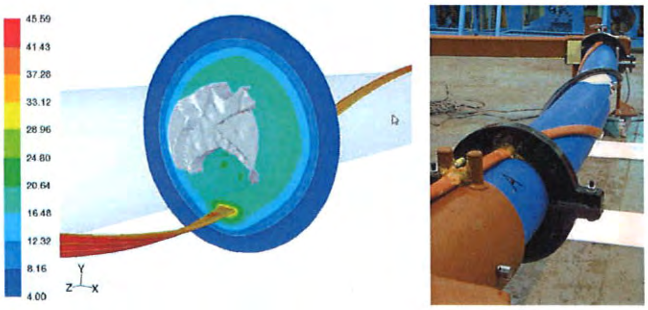

Figure 4. CFD and bending trials.

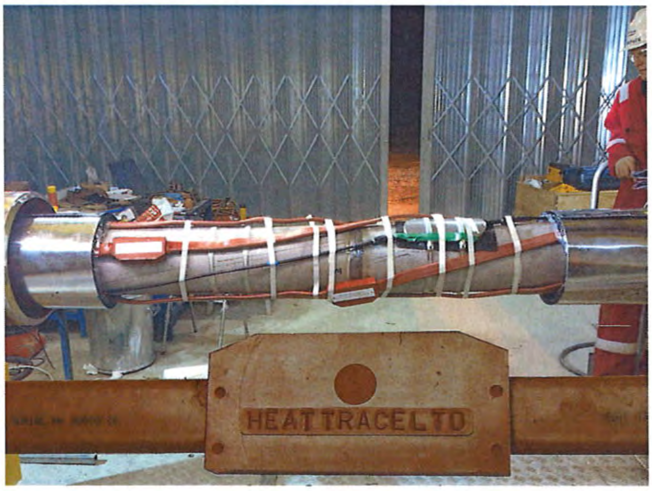

Figure 5. Stalk tie-in showing splices and ETH splice.

The primary hydrate mitigation solution on the Islay project is the injection of methanol at specific low points along the pipeline, including both ends and a midline injection point 2 km from the Islay well. How to incorporate this tee, while maintaining a continuous heating system along the pipeline, offered up a significant design challenge. The innovative solution chosen was a reelable PiP bulkhead complete with channels to allow the ETH and FO cables to bypass what would later become a methanol injection tee. This was achieved by drilling the methanol port offshore on the *Apache II* pipelay vessel and welding the methanol injection pipework in situ. Introducing a structure such as this while offshore would have required unnecessary offshore splicing and testing which, while possible enabling multi-trip campaigns, was rendered unnecessary for the Islay project as a base case. However, contingency procedures were developed to allow a readymade tee to be inserted if required.

The main components that make up the ETH-PiP were carefully selected during the early stages of the Islay project to ensure the delivery of a fully qualified and robust product. These included the electrical heating cables and fibre optic cables. Specifically, the heating cables were manufactured and supplied by HTL. The company was contracted to provide and aid installation of the main body of the ETH system on the pipeline. HTL, a British manufacturer, with global capability and almost 40 years' experience in the heat tracing industry, provided its well established and proven 'Longline' heating cable product to Technip for installation at the company's Evanton spoolbase, near Inverness. Both HTL and the fibre optic cable supplier developed bespoke splicing solutions to allow the jointing of cables both onshore and offshore and performed numerous trials to ensure the quality of their respective products. The heating cable inline splices and star connection joint use low profile, fast curing, moulded joints – developed specifically to allow location within the PiP annulus. The flat foil conductor and cable construction of the Longline cable results in a lower cable operating temperature when compared with round conductor cable constructions. This greatly improves efficiency, safety and system life.

Construction

The pipeline was constructed at Technip's Evanton spoolbase, where a brand new cable application machine (CAM) was incorporated into the long established pipe construction facilities. Evanton spoolbase has more than 25 years' PiP construction experience and the management and workforce were fully involved in the design, build and commissioning of the CAM prior to pipeline assembly. The CAM allows the cables to be installed on the pipe during the PiP assembly process seamlessly integrating the ETH system into the operation. The process involves the assembly of circa 1 km ETH-PiP 'stalks', by inserting the PiP flowline into the carrier pipe using a hydraulic push machine (HPF). During this process the cables are wrapped onto the flowline by the CAM and, in between HPF push strokes, the passive aerogel insulation and nylon centralisers are installed. Following construction, each stalk was subjected to a full suite of electrical and optical integrity tests including: continuity resistance (CR), insulation resistance (IR), time domain reflectometry (TDR) and optical time domain reflectometry (OTDR).

On completion of the ETH-PiP stalks, and on arrival of the *Apache II*, the pipeline was reeled onto the vessel in stages using standard reel-lay procedures. On completion of each stalk, reeling was paused to allow the next stalk to be added. This required welding operations, as well as splicing of the electrical and optical cables, which was carried out onsite by the cable suppliers without incident.

Further testing was performed after each stage to ensure the integrity of the pipeline throughout the process.

Since the cables are installed within the annulus of the ETH-PiP, a method of connecting an external power supply to the trace heating and FO cables was required. Technip designed a breakout termination assembly to allow this connection. The essential requirement of this assembly was to allow the electrical/FO connection, while maintaining the integrity of the PiP annulus, which is critical to thermal performance of the pipeline. A series of subsea connectors are installed within the termination assembly to facilitate this and provide a double seal barrier for seawater ingress. The subsea connectors were chosen due to the availability of a fully welded solution, allowing the company to create a welded primary barrier against seawater ingress. This was supported by a series of elastomeric seals, as well as a secondary barrier made up of metallic seals and glass to metal and epoxy seals within the final (dry) connector. This unit was constructed offline of the pipeline and, following a significant pressure testing programme, installed onto the end of the pipeline on completion of the spooling phase. The

Figure 6. Islay ETH termination assembly on *Apache II*.

Figure 7. Installation of Islay ETH-PiP.

termination assembly was welded to the pipeline onto the *Apache II* ramp before performing cable splicing and completing the carrier pipe with half shells. This allowed the final integrity tests to be performed on the full pipeline on the vessel prior to departure.

Conclusion

The *Apache II* successfully installed the pipeline in January 2012. In situ testing was performed on the electrical and optical circuits during a subsequent DSV campaign in February/March 2012.

In conclusion, the ground breaking Islay project has provided the world's first subsea ETH-PiP, a hydrate mitigation technology that can provide oil producers with an efficient active heating option for future subsea developments. This provides the potential to unlock challenging reservoirs that were previously not considered as cost-effective, as well as optimising oil recovery by providing a solution with significant OPEX savings as compared to other heating technologies. Such OPEX savings, possible due to the comparably low overall power required by the system, combined with the compact topside power supply requirements, or footprint, make ETH-PiP an attractive alternative.