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► **8 septembre 2016 - N°4 - Technology**

PROCESS: A pipe-in-pipe insertion operation under way at ITP's manufacturing facility in Ranville, France.

Taking pipe-in-pipe to new depths

The thermal benefits of pipe-in-pipe are well known, but installation challenges have so far limited how deep the technology can go. Pipeline experts at France's ITP tell Russell McCulley about an innovative and cost-effective method to bring pipe-in-pipe systems to unprecedented water depths.

Dry insulation systems such as pipe-in-pipe (PiP) offer considerable advantages in many situations. With a better thermal performance than wet insulated pipe, the technology is particularly well suited to long tie-backs where flow assurance can be challenging. Whereas the weight of PiP is a benefit to on-bottom stability, vessel top-tension limitations make it difficult to install in extreme water depths using typical J-lay methods.

"In about 2000-metre water depths, the hang-off weight becomes a design driver" for PiP systems, says Christian Geertsen, R&D manager at ITP InTerPipe.

"You can still design pipe-in-pipe, but from about 2500 to 3000 metres it becomes very expensive, and very difficult, if not impossible, to do it with sliding pipe-in-pipe design."

In a sliding PiP system, field joints — the term used to describe the points where rigid pipe segments are joined during installation — require welding of both the inner and outer pipes. ITP's standard flowline system differs in that only the inner pipe is welded in field joint operations. A customisable layer of microporous material, manufactured under the trademark Izoflex, provides insulation between the pipes, which are swaged down at the ends of each segment.

To join the pipe segments offshore, the pipe ends are welded together and a field joint sleeve is placed over the weld and the swaged section of pipe. Once in place, the cavity between the sleeve and joint is injected with a resin that cures in about

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Photo: ITP

QUICK CONNECT: ITP's rapid field joint sleeve pre-inserted onto a pipe-in-pipe double joint ready for offshore installation. The system requires only one offshore weld of the inner pipe.

two minutes. The method is considerably faster than welding both inner and outer pipes, says Geertsen.

"For the installation vessel, it's close to installing a single pipe. They only have one weld to do per joint."

ITP's deepest installation of its PiP system was for Tullow Oil off Ghana, in water depths of about 2000 metres. But operators are considering projects in much deeper locations where the thermal performance of PiP could be crucial, says Wayne Grobbelaar, ITP's business development manager.

"The thermal performance of pipe-in-pipe is typically three to four times that of wet-insulated pipe," he says, using the term to describe pipe with an exterior coating of insulation.

A system is assigned a "U-value" to measure the rate at which heat it is lost to the environment, with a lower U-value indicating better insulating ability. The measurement is described in watts per square metre, per degree Kelvin, or $W/(m^2.K)$.

Image: ITP

JOINED UP: A cutaway rendering of ITP's rapid field joint system with Vallourec's PURE pipe ends.

Typical wet-insulated pipe has a U-value of 2.5-3.5 $W/(m^2.K)$, he says. ITP's pipe-in-pipe provides insulation with a U-value of 0.5-1.0 $W/(m^2.K)$, allowing for much longer cooldown times and hence longer tie-backs between outlying wells and floating production, storage and offloading vessels or platforms.

PiP's thermal performance "buys you time" to implement flow assurance strategies by slowing the hydrocarbon cooling process, Geertsen says.

"It also gives you flexibility in terms of fluid properties and fluid composition," adds Grobbelaar. "Good insulation gives operational flexibility."

While often seen as a more expensive option, PiP can be more economical when "the operator takes a system approach", Geertsen says, "where he doesn't just compare pipeline with pipeline, but looks at it comprehensively. The PiP allows downsizing or eliminating big-ticket items such as the back-up systems, the weight penalty (of chemical storage) on the platform, expansion loops and so on."

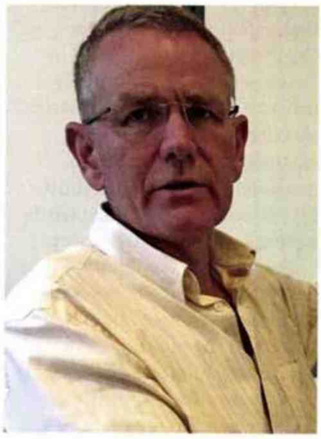

Photo: Russell McCulley

"Given the times, everybody is willing to look at a new idea that has a technical rationale behind it."

Christian Geertsen, ITP »

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FIELD READY: ITP pipe-in-pipe flowline system for S-lay and J-lay.

Photo: Vallourec

PRECISION ENDS: The upset ends on Vallourec's PURE pipe are machined on both the inside and outside for a better weld.

Upset ends

Those advantages mean little if a subsea development is too deep to take advantage of PiP technology, either because the installation is deemed too expensive or technically infeasible. Recently, ITP teamed up with Total and tubular manufacturer Vallourec to examine how the depth limits for PiP could be extended while keeping costs within reason.

The physical challenge was to create a system that could hold up to the extreme weight loads placed on the pipe during ultra-deepwater J-lay installation.

"When you're hanging a catenary off an installation vessel, you have all the weight going through the inner pipe, whilst supported on the outer pipe," says Grobbelaar.

"If you go into more than 2000 metres of water, at some point it becomes so heavy that you're straining the metal. That's why we started to look at improving the design for ultra-deepwater."

Vallourec has for several years been developing PURE, a patented product family of pipes with upset ends. In ITP's current PiP system, the pipe ends at the field joint are the same thickness as the pipe body. The companies conducted a series of tests that paired ITP's field joint technology with Vallourec's upset, or thickened, pipe end sections.

"Pipe with an upset end is something Vallourec has been developing for a number of years, for different applications," explains Geertsen. "In our case, it's very practical. The only place where we really need the steel is in the field joint where all the stress goes into the inner pipe. It avoids beefing up the pipe over the whole length and putting a lot of steel in there.

The Vallourec system upsets the inner pipe at pipe ends. So you can put in more material just where you need it."

The upset end distributes the stress over a wider area, enabling the PiP to be installed in ultra-deepwater. Because the upsetting process thickens the pipe both inside and out, the ends must be machined, which results in a precise fitting.

The PURE end gives "very good tolerances on the fit-up of the weld, because it has been machined on OD and ID, without eccentricity," Grobbelaar says, using abbreviations for outside and inside diametre. "The extremities match well."

The additional thickness at the pipe ends provides the same strength as the areas of pipe where stress is distributed among both the inner and outer pipe. That means a section of pipe need not be bulked up throughout to give it the strength to withstand the

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ROUNDING APPROACH: ITP's pipe-in-pipe during fabrication, before swaging.

load during deepwater pipelay operations.

"The weight penalty over that short field joint location in one 48-metre joint is minimal, so we can double the reach. We can go from 2000 to 4000 metres of water," he says.

Enabling technology

The study looked at a range of pipe diameters in various conditions — six inch, eight inch and 12 inch inner pipes, in water depths from 2000 metres to 4000 metres. Detailed analysis showed that the field joints with Vallourec's upset ends withstood the installation and operational bending loads, maintaining stress within the recommended limit of 350 megapascals (MPa), the equivalent of about 50,000 psi, well below yield stress for X65/X70 pipes.

Modelling tests concluded that the system would allow installation at extreme depths without any significant changes to current methods and that pipelay could be done with existing deepwater construction vessels. Only the largest of the pipe sizes under consideration could require further optimisation for 4000-metre depths.

At about 3000 metres, the outer pipe needs to be thickened about eight milimetres to keep the overall axial stress within 350 MPa, Geertsen says. ITP is working with Vallourec and its Serimax welding division to optimise the pipe properties in order to reduce the pipe weight by as much as 20%.

PiP fits well with the trend toward longer tiebacks in deepwater that take advantage of existing infrastructure to cut costs, he says.

"Thermally speaking, ITP pipe-in-pipe can reach 50 to 100 kilometres out. So one can consider this both for infield and export pipelines."

In long back-to-beach tiebacks, Geertsen says: "A pipeline can lose about half its entrance temperature over that kind of distance. The challenge becomes, how do you put enough energy into the hydrocarbon to make it flow over that distance? That requires the installation of subsea pumps, and so on — a change in infrastructure. The industry is going that way with subsea equipment, but it's not quite there. It's still a lot of one-off projects."

ITP has also worked with other industry players, including Subsea 7, to develop high-performance and electrically trace-heated PiP (Upstream Technology 03/2016), both seen as enablers for future developments. Further research and development is taking place that will improve the technology and economics of long subsea flowlines in extreme depths, Geertsen says.

Photo: Russell McCulley

"We can go from 2000 to 4000 metres of water."
Wayne Grobbelaar, ITP

"What's really nice for us on this project is being able to work together with Vallourec and Total. We've got an interesting dialogue going on, with many 'what if' questions being asked and trying to look at new ideas. Obviously, given the times, everybody is willing to look at a new idea that has a technical rationale behind it."

The recent study, says Grobbelaar, provides both a technical rationale and an economic justification for ultra-deepwater deployment of PiP.

"It's a solution that doesn't require any further qualifications," he says. "And we think it will be an enabling technology when the oil companies get back into deepwater.

"We are conscious of trying to make systems that are cost effective for the developers. What can be done to enable the developments? That's what is important." U

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