'The industry has been seeking a solution to the problem of welding high-integrity risers for years.'
Steve Hatton

Shrink fit for purpose

The novel application of an established technology lies behind the manufacture of the world's first ultra-high pressure, large-bore drilling riser.

Venture Production, one of the UK's latest generation of oil and gas operators, is putting together a high pressure, high temperature (HPHT) drilling campaign in the North Sea for the fourth quarter of next year that looks set to break the industry mould. The company is aiming to use a jackup rig (it has already secured the *Noble Scott Marks* currently under construction in China) equipped with a surface blowout preventer (SBOP) to drill a series of subsea wells across several of its central North Sea assets.

The SBOP will provide cost and operational advantages. However, in order to complete the wells at the seabed, Venture will need a drilling riser that offers full-bore (18¾in) access and can contain the full pressure of the reservoir, which could be in excess of 12,000psi. The problem is that no company has been able to provide a riser of this kind, at least until now.

Venture has liaised closely with a group of three Acteon companies, Claxton Engineering, 2H Offshore and the newly established Subsea Riser Products, in designing a unique riser for its 2009 campaign. A notable feature of the riser is its flange connections, which will be shrink fitted to the individual pipes.

Speaking for Venture Production, senior drilling engineer Alistair Montgomery points out that HPHT drilling is on the increase across the industry, and that, in a tight rig market, a riser that enables Venture to employ a jackup rig equipped with an SBOP and that provides the full-bore access needed for subsea well completion work is highly significant. Venture is believed to have considered other options for the campaign, including retrofitting the *Scott Marks* with a subsea BOP to reduce the pressure requirement on the riser. In other instances like this, operators have resorted to more costly semisubmersible rigs, which are generally better suited than jackup rigs to handling subsea BOPs, and also to the use of complex, multiple-bore riser systems.

A complete shrink-fit flange produced during the development and testing programme. The short piece of main pipe is held tightly within the body of the flange.

Montgomery stresses the quality of the collaboration that lay behind the development of the drilling solution, which included tree supplier FMC Technologies and drilling contractor Noble Drilling as well as the Acteon companies. 'Process safety, operational efficiency and ensuring effective systems interfaces were among our top concerns,' he says.

Shrink-fit flanges

Venture's central North Sea assets are not in particularly deep water; in fact, the deepest is in about 120m. The riser will therefore have up to 13 main sections, each 30ft long, plus fatigue-critical, tapered stress and tension joints at either end. As is common practice, the individual pipes will be connected to each other using bolted flanges. The question in the case of this ultra-high-pressure riser was how to attach the flanges to the main body of the pipes.

The answer was not easy, as the conventional option, welding, is not really practicable. Using a normally weldable grade of steel, say 65ksi, would require a pipe wall thickness of around 75mm. Welding pipe of this thickness is extremely difficult, especially when the final weld properties and fatigue performance are governed by NACE sour service requirements, as for this project. Actually, welding is not the only problem. In the first place, manufacturing pipe of this thickness is far from straightforward, and the weight of a complete riser string of this nature would be enormous. Selecting a high-strength steel would reduce the wall thickness needed: going for a 110ksi steel would mean having a wall thickness of about 30mm. However, it is impossible to weld such steels successfully.

This whole problem surrounding welding has been resolved by using a shrink-fit process to attach the flange connectors to the pipes. Steve Hatton, founder of 2H Offshore and a vice-president of parent company Acteon, came up with the idea, which he believes will revolutionise the fabrication of higher-strength, lighter-weight risers with improved fatigue performance.

Hatton says: 'The industry has been seeking a solution to the problem of welding high-integrity risers for years, and with the current increase in HPHT applications, the problem has become critical. Shrink fitting offers an excellent solution. Venture has recognised this and has supported the technology development and fast-tracked our qualification process.'

Development and testing

Shrink fitting is a simple process in principle. However, there are several issues that have to be understood to guarantee repeatable performance to the level demanded by the offshore industry, particularly for critical HPHT riser applications. 2H has therefore conducted a thorough development programme to

'A cost-effective step change in drilling practice.'
Dannie Claxton

prove the process and confirm earlier finite element analysis work.

The main element of the programme has involved preparing a series of shrink-fit test pieces at a forge in Sheffield, UK. The machining of component profiles and finishes has been tightly controlled during the assembly process, as has the heating of the flange body using induction heating coils. Mating the two components was expected to present practical challenges; however, precise alignment when the pipe is stabbed into the flange body has avoided any problems with the two parts jamming. Simply allowing the assembly to cool completes the process and generates a high-quality structural connection and a gas-tight seal.

Rigorous load and pressure testing, witnessed by Bureau Veritas, has been conducted on a series of joints made using the 80ksi steel eventually chosen for this project. There is no reason why the shrink-fit process cannot be applied to 110ksi steels. In this specific case, the designers were keen to avoid an excessive hardness rating, which would put the riser outside the NACE limits imposed by the operator. The joints have successfully completed hydrostatic pressure testing up to 13,500psi (equal to 90% of pipe body yield strength) under various external tension and bending loads. In addition, gas pressure testing has been performed to 12,200 psi.

The integrity of the shrink-fit joint relies primarily on the radial contact force generated as the flange cools and shrinks onto the end of the pipe. The friction generated at the interface is further enhanced, however, by surface geometrical and mechanical features that 2H has incorporated into the design. While patents on the technique are still pending, the company is reluctant to disclose too many details of these features.

Full-scale manufacture

Responsibility for the shrink-fit process and manufacturing the Venture riser is now with Subsea Riser Products, the company spun off from 2H earlier this year (*OE* March).

Forging the main pipe sections has already commenced at two plants in France and Italy. The flanges will be forged once the main pipes are finished, and then extensive machining will be required before the flanges are shrink fitted to the ends of the pipes. Once the work is complete, detailed quality control checks will be carried out before the entire riser is delivered to Venture in September 2009.

Lead contractor on the project is Acteon company Claxton Engineering, based in Great Yarmouth, UK, which specialises in drilling riser rental and sales. Engineering director Dannie Claxton is proud of the fact that the Venture riser is the first of its type in the world. He believes it represents a cost-effective step change in drilling practice, which, significantly from his company's business standpoint, he expects others to follow. Claxton will provide a range of ancillary equipment, including an umbilical, wellhead and BOP connectors, a tensioning ring, and a hydraulic power and control system. In addition, a team from Claxton will be responsible for running and pulling the riser on the rig, and for its inspection and maintenance.

Beyond the current project

The development of the shrink-fit flange is the key to this entire Venture project, and the chances are that it will find broader application for both shallow and deepwater riser systems in the future. It certainly seems to present the opportunity to use high-quality and ultra-high-strength steels, which previously could not be used owing to welding limitations, in critical riser applications.

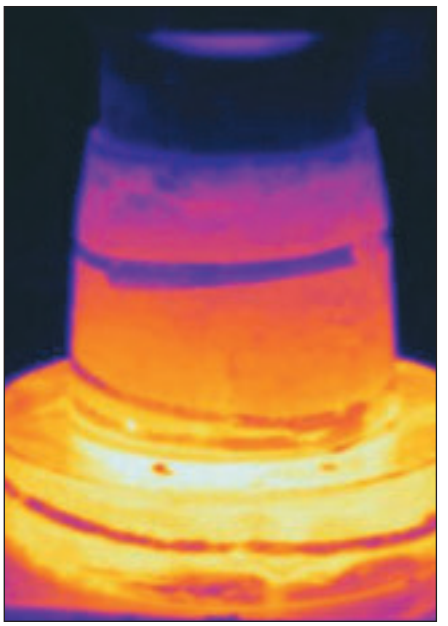
The Acteon companies involved in the current project are already focused on HPHT applications in deep water in the Gulf of Mexico, such as the BP Kaskida development, which may require risers capable of working at even higher pressures than the Venture Production system.

Shrink-fit technology, it is confidently claimed, can easily be extrapolated for use at much higher pressures than the current system and is only limited by the availability of suitable pipe. Risers with a bore of 18¾in and rated to 20,000 psi should be possible.

The companies are also promoting the process as a way of reducing the cost of producing the tapered stress and tension joints for riser systems, which are normally manufactured complete with flanges by machining necessarily massive forgings.

Other applications being mentioned involve riser joints with complex non-ferrous metallurgy such as titanium and aluminium; and an interesting point is being made that the shrink-fit process could easily be used to join dissimilar metals. **OE**

Pressure testing of completed flanges under various tension and bending loads using powerful hydraulic jacks. Some flanges were tested to destruction to see how the various sealing mechanisms performed.



A shot of the flange during heating taken with a thermal imaging camera. Induction heating has proved to be a highly effective and controllable method of preparing the flanges for connection.