Revolution Valve Technical Briefing

Reducing Cost and Increasing Performance in Well Intervention

No matter the economic environment, there is always the need for novel technology that can provide performance improvements and enable the oil and gas industry to access more challenging well environments at a lower cost, particularly when that technology is focused on safety.

One such technology is Interventek's new Revolution safety valve, which won the Emerging Technology Award at the 2016 SPE Offshore Achievement Awards. The valve enables well intervention operations to be carried out with more reliable well control safety measures in place at a significantly lower cost.

Background

Having seen the challenges being faced by the maturing well intervention industry, and the high costs and technical shortcomings of conventional products and methodology, Interventek decided to create a new well control safety valve that could outperform the competition and significantly reduce costs. This was achieved both in terms of:

a) product design
   - through its simplicity
   - the materials used in manufacture and its
   - ease of maintenance and after care

b) in terms of system engineering
   - by reducing the need for multiple valves and

c) in terms of operating costs
   - by enabling light well intervention via riserless methods rather than using costly rig based riser equipment.

This is a true innovation in well intervention and will help to enable cost effective production optimisation for late life fields.

Overview

The Revolution Valve is a novel shear and seal safety valve designed to cut slick line, braided cable and coiled tubing should the need arise during intervention operations and thereafter contain well pressure. It can cut intervention media up to and including 2" outer diameter, 0.203" wall thickness, 147 KSI tensile strength coiled tubing and can operate in deep water, high pressure, high temperature environments, exceeding the capability of all other comparable products on the market. A compact design, through the use of a rotary actuator, means it can be used for in-riser and slim-line open water interventions.

revolution™ valve

Why is it needed?

Gavin Cowie, Interventek's managing director, explains the need for the Revolution Valve's development: "Conventionally, ball valves have been used for shear and seal well control but they were never originally designed as a cutting tool. They are often subjected to damage during the cutting process which then compromises their sealing capability so they have to be used in series to compensate for their short comings. Furthermore, moves towards larger bores and higher-pressure environments, and new requirements in API 17G, particularly around fatigue capacity, are adding to their shortcomings.

"This combination of requirements can be met by shear ram type devices, but such devices have their own limitations. They typically utilise elastomeric seals for containment of well-bore fluids which have limited temperature, gas service and life performance, and they are large and cumbersome. Many upstream valve applications occur where space is severely restricted and in such circumstances, it is simply not viable to utilise ram type arrangements with their associated large, projecting cylindrical actuators.

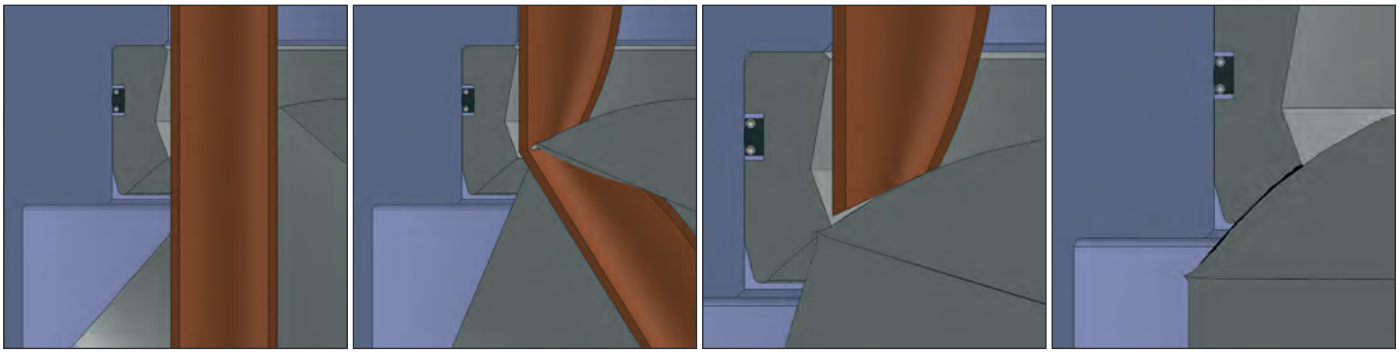
"Interventek has designed a compact, elastomer free valve that can shear and seal in one movement with separate cutting and sealing components, which can far outperform both these existing products."

Design in Detail

Looking more closely at the design principal behind the Revolution Valve, its key functional differentiation is the separation of its cutting edge from its sealing surfaces. This separation enables the sealing components to be protected from cutting induced damage, unlike ball valves, as illustrated in Figures 1 and 2.

The Revolution Valve goes a step further in protecting the sealing surfaces by ensuring that they are held clear of the shearing edges during the closure cycle. Only after the sealing surfaces have been rotated past the potentially distorted shearing edge are they permitted to lift into position and initiate the sealing functionality. During development testing, the Revolution Valve has provided repeated post-shearing hydrostatic and gas containment at both low and high pressures.

Figure 1 - Problem



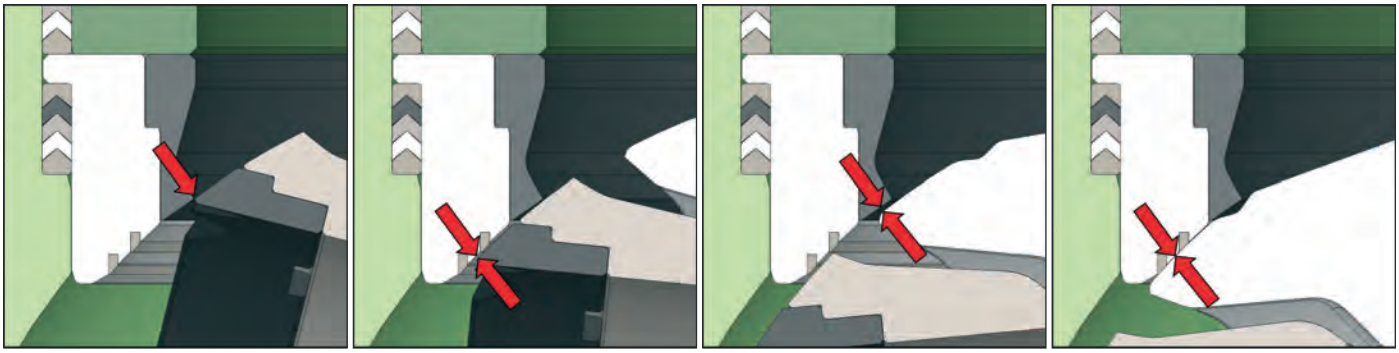
Typical ball and seat shown closing on coiled tubing

Shearing edge deforms

Components now clash

Sealing faces damaged

Figure 2 - Solution



Closely toleranced shearing edges

Seat clearance

Flapper clearance

Sealing

Enhanced Sealing Capability

The Revolution Valve utilises resilient rather than elastomeric sealing at interfaces on the produced fluid boundary. These seals are manufactured from a high performance thermoplastic material with outstanding temperature, life and gas service performance. Elastomeric elements can also be provided as secondary or tertiary seals if desired.

Optimised Shearing Components

Separating the shearing and sealing functionalities also has a further benefit - each component can now be optimised for its intended purpose. Intervention media comes in a variety of forms and each of these presents a challenge to a shearing device. Slickline is exceptionally hard, braided cable is comprised of very small, individual strands and coiled tubing is both geometrically substantial and exceptionally strong. A shearing device which is to be effective across all these media types must be strong, hard, sharp and crucially closely toleranced. The dedicated shearing components in the Revolution Valve enable all these requirements to be fulfilled.

Optimised cutting edges are provided on both the static seat and the rotating saddle via cutting inserts. These provide the hardness, strength and sharpness required to repeatedly cut the various media types.

Coiled Tubing Cuts

Stiff components ensure that the edges cannot deflect and inadvertently allow any media to lie across the seal surface in an uncut state. The saddle itself is a substantial, robust component which is rotationally mounted to the valve body via stout torque shafts. This combination of characteristics eliminates virtually all deflections during the highly loaded portion of the shearing process. The device is thus able to maintain an optimised, close shearing action with no risk that the cutting edges might separate and allow, particularly the fibrous braided media, to lie across the seat. During development testing, the Revolution Valve has repeatedly cut multiple samples of slickline, braided cable and coiled tubing and thereby confirmed the device as an effective and superior shearing solution.

Half the Cost, Twice the Performance

It is also worth comparing the Revolution Valve to tandem valve arrangements which provide shearing and sealing in two separate devices. The single Revolution Valve is lower in cost and smaller in form – both highly desirable qualities - however performing the shear and seal in one device eliminates the need for any intermediate, typically manually initiated, step of removing the obstruction from lying across a second sealing valve. This simplifies operations and improves safety.

High Torque Rotary Actuators

The Revolution Valve provides further innovation through its use of compact, high torque, fractional turn rotary actuators. In-riser subsea equipment must function in an extremely confined envelope and consequently mechanical efficiency is paramount. The shearing action of the Revolution Valve is essentially rotational in nature and the most effective means to provide the required force is a directly acting rotary actuator.

The device utilises two such actuators located on either side of the body and these are directly connected to the saddle via stout torque shafts. The actuators are rated for 10,000psi (10K) working pressure and they develop sufficient force for shearing all common sizes of coiled tubing. The total fluid requirement of the actuators is only 1.5 litres.

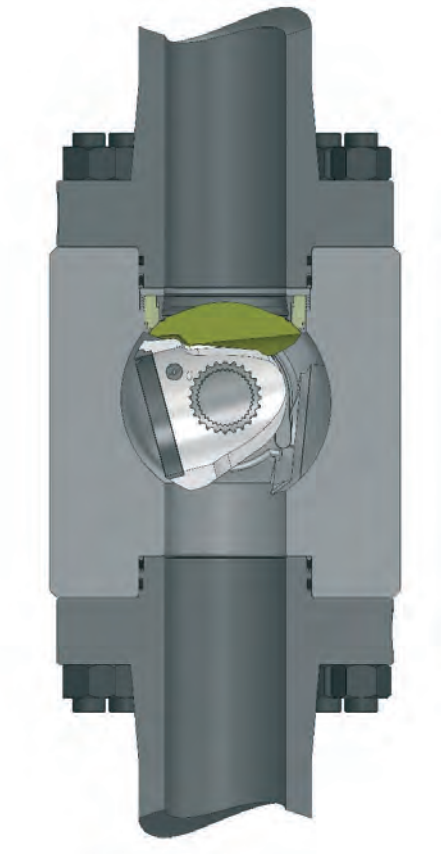
By locating the actuators on the outside of the device, the hydraulics are separated from the wellbore fluids. This ensures that the actuator seals operate in only a clean hydraulic environment and thereby the reliability of the device is significantly improved. In early testing the device has operated over thousands of cycles and continued to deliver acceptable performance.

Compact, Robust and Reliable

Control system requirements are also much simplified, as the 10K pressure rating of control lines, valves, solenoids etc. is de-coupled from the pressure rating of the valve. This enables low cost, off the shelf components to be used for even 15,000psi or 20,000psi rated valves.

The compact nature of the valve and actuator components is extremely beneficial for subsea in-riser applications. A short valve is more easily accommodated within drilling BOP's which have irregular ram spacing which can frequently be very restrictive. Diametrically, the compact internals leave substantial material available in the body and this can be utilised to provide preloaded end connections, such as a flange. Pre-loaded end connections are mechanically superior to non-preloaded connections and extremely desirable where cyclic loading is likely. The in-riser market has been seeking such connections for many years.

Overall, the Revolution Valve uses fewer, simpler components and these are combined to produce a robust, fit for purpose, low maintenance product with significant benefits. Historically, the cost of ownership for this class of device has been punitive, as frequent and expensive maintenance was required to ensure equipment readiness. The Revolution Valve can be assembled quickly and does not require any specialist tooling or extensive training or knowledge. The reliability it has exhibited during preliminary endurance testing over thousands of cycles promises a huge reduction in the required maintenance frequency. The design itself is economical to manufacture and utilises common oilfield low alloy steel for all major structural components.



In-Riser Valve – Closed Position

Applications

Although conceived as the core valve of an in-riser landing string system (pictured left), the Revolution Valve is a truly innovative and versatile arrangement with many applications. The capabilities of the valve mean that it is suitable for use in surface intervention, subsea in-riser completion installation and intervention, open water well control package and EDP valves, abandonment tree saver valves (a compact lightweight tree-on-tree system for use during well abandonments to allow well access without overstressing the xmas tree), subsea lubricator valve assemblies or any application that requires a compact and robust shearing and sealing device.

To date Interventek has delivered 6 5/8" 10K psi and 6 3/8" 15K psi versions of their Revolution Valve to the field. Designed to be suitable for in-riser well completion and intervention landing string valves, they can be tailored to suit, for new subsea well developments and heavy intervention from mobile offshore drilling units using a drilling riser or BOP stack.

Interventek recently agreed a deal to supply the 15K psi in-riser valve to US-based service company PRT, operating in the Gulf of Mexico and have licensed a surface version of the valve to Hunting Energy Services.

Interventek's Open Water Well Control Valve

World's First 20K In-Riser Valve

At OTC in May 2017, Interventek launched a world first in the form of their new 5 1/8" 20K psi configuration, having successfully completed initial testing. This ultra-high pressure, high temperature (HPHT) version of their in-riser valve is able to withstand working pressures of 20,000psi and temperatures up to 350 degrees Fahrenheit. There are currently no other 20K in-riser well intervention valves on the market and the new product line was developed to support moves into more challenging HPHT, deep water well environments, particularly in the Gulf of Mexico.

A Versatile LWI Solution

A further application variation has also been developed, which utilises a linear form of the separation principle. Conceived as a shear and seal device for light well intervention safety packages, the Open Water Well Control Valve maintains all the functionality of the in-riser valve but is additionally capable of cutting solid wireline sinker bar, which pushes the boundary of traditional wireline/coiled tubing class shear and seal valves.

World's First 20K In-Riser Shear-Seal Safety Valve

Summing up

Summing up, Gavin Cowie says: "As a young company with a game changing, disruptive technology, we are pushing against people's natural, inbuilt preference to choose familiar, conventional methods. However there is a real need to adopt new ideas in order to be competitive in today's market, and as our products are now proving themselves in the field through cost reduction and unparalleled performance we are seeing a real shift in focus with clients approaching us to help solve additional technical challenges.

"Developing our 20K in-riser valve was not only to meet the HPHT need but also to prove that such a solution was possible! Our design is flexible and scalable and doesn't suffer from the shortcomings of other technology so it was easy and natural for us to develop what we believe is a world-first. We hope the industry continues to embrace new ideas and innovative problem solving to accelerate its advancement going forward."

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