Improving Valves for Reliability, Robustness

Safety, reliability and robustness are key factors in valve re-engineering and redesign for deeper wells, larger wellbores or HP/HT environments.

By Scott Weeden
Contributing Editor

With oil and gas drilling and production having to deal with HP/HT environments, more corrosive fluids and greater water depths offshore, the industry is challenged to design valves to operate safely and reliably.

Many valves were designed years ago when environmental demands were not as stringent. What worked at 2,000 psi or 3,000 psi isn't always as efficient or safe at 10,000 psi or 20,000 psi. Manufacturers know the valve requirements and are asking questions such as how can that piece of equipment be more robust and reliable, is that feature needed, is there a need for that much pressure and how do we make sure this failure doesn't happen again?

John Sangster, technical director and co-founder of Interventek Subsea Engineering, believes that the future of valve technology lies in the creation of simpler, more fit-for-purpose designs that are re-engineered from the ground up to reduce cost and suit the logistical requirements of projects. Adapting existing solutions is simply not viable when addressing the increasing safety challenges faced by deeper, longer, larger bores or HP/HT wells.

"Over the last 20 years or so, in-riser valves have developed into extremely complex designs as bore size, pressure and temperature requirements have increased. Complexity, along with the use of exotic materials, has increased costs but reliability has been reduced and forced some operators to consider if the use of subsea landing-string systems can continue," he explained.

"Interventek's new valve technology not only provides superior shear and seal capability in a single unit, but vastly increases reliability and provides HP/HT capability at a significantly reduced cost leading to major savings for the operator," he continued.

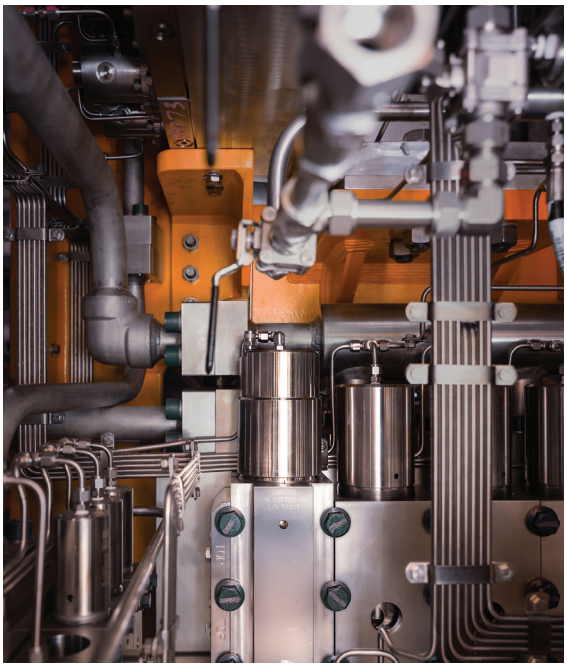
"Open-water intervention valve manufacturers have also taken the 'one-design-fits-all' approach, but this creates a huge burden on the system provider as they are invariably left with an unnecessarily high shearing capacity and operating volume. This approach has a major impact on the system's weight, control volume requirement and ultimately vessel size and type," he added.

"In times of low oil price where low cost, fit-for-purpose solutions are increasingly desirable this is an out-of-date, unrealistic approach. The limited valve choice on the market has a direct implication on operational cost. Technology such as ours is hugely exciting because it is enabling and disruptive. We are changing the way the industry has been conditioned to operate," Sangster emphasized.

BOP valve redesign eliminates shock

Subplate-mounted (SPM) valves have been around for more than 30 years on subsea BOP stacks. The pressure and shearing requirements have gone from about 1,500 psi to 5,000 psi. The fundamental design had not changed much in that time, said Frank Springett, director of engineering for research and development and the NOVOS product line for NOV.

The SPM valve uses a water (98%) and glycol (2%) mix as the hydraulic fluid in an open-loop system. With an open-loop system, the fluid is pumped subsea and then exhausted into the ocean since the fluid is mostly water.



NOV discovered that the opening and closing of the SPM valves caused the shock in subsea BOP systems. By designing a closed-center valve system, the company was able to virtually eliminate shock. (*Photo courtesy of NOV*)

"SPM valves have an open center and are two-position [open and close] and are three-way [work port, pressure port and tank port]," he explained.

After researching how the valves work, NOV discovered that the opening and closing of the valves is what causes the shock in subsea BOP systems.

"That shock is not a function of opening fluid to a piston or something like that. The reason you get this shock is because of the open-center configuration. Pressure is actually venting to the tank. The short burst and sudden stop of pressure creates the shock in the system," Springett said.

After instrumenting a system to see how everything works, the company took a look at the valve itself, including the design of the spool and cage.

"We designed a system that was a closed-center valve. What that means is that as the valve is transitioned all ports are not open to each other. It was pretty remarkable how we were able to virtually eliminate the shock in the system," he continued.

"The big plus to that is BOP reliability. One of the big pieces of BOP reliability is hoses, piping and tubing. By eliminating the shock that we produced from the fundamentals of a conventional, old-school SPM valve, we not only impact the reliability of the valve because we don't have the shock associated with it, but we also impact the reliability of the entire system since it increases the life of all the components that hydraulic fluid comes in contact with such as pressure regulators, shuttle valves, piping, etc.," Springett emphasized.

On the stream side of the valve, NOV saw high shock loads, and the SPM valve is right next to the regulators. Shuttle valves were also affected by the shock.

"We confirmed that eliminating the shock was a really, really important aspect in robustness and reliability," he added. "We could have stopped a eliminating the shock in the system but we didn't. We looked at every aspect of the valve and designed around reliability.

"We redesigned the seals to handle large extrusion gaps. We can rework the valve pockets in the field, which allowed us to fundamentally redesign the pod to eliminate leak paths. We eliminated troublesome fasteners from the design and utilized and placed wear bands that are more tolerant to contamination. We designed components symmetrically so parts can't be installed backwards or upside down. The list goes on and on," Springett said.

For existing systems, the valve block is changed and the new one is bolted in. There are no fundamental changes to the control system, he added.

"When our engineers are looking at designing for robustness and reliability, the first question is not, 'How do I make that item more reliable?' Their first question is 'How can I eliminate that item?' This is the essence of the design philosophy of the Low Shock SPM valves," he said.

Remote partial stroke testing

Safety in today's hazardous process piping environment is critical. "At Emerson we want to do our part to make sure our customers who work in these plants go home safe to their families at the end of the workday," said Shawn Statham, global product manager—actuated safety systems for Emerson Automation Solutions. "We're a manufacturer, yes, but we want to come together with the people who operate these offshore platforms and production facilities and partner with them to develop more reliable and safer solutions.

"Safety shutdown systems (SSDS), or safety instrumented systems (SIS) to be specific, continue to be a significant area of focus around the world. SSDS provide an additional layer of safety that help to protect personnel, the environment, and assets, etc.," he continued.

Over the last 20 years the industry has seen a

Emerson has provided four HIPPS top-entry API 15000 FCT valves with Biffi actuators for an offshore platform in the North Sea. *(Photo courtesy of Emerson Automation Solutions)*

continued evolution of standards designed to address safety including the International Electrotechnical Commission (IEC) standards 61508 and 61511 along with International Standards Association (ISA) Standard 84.01. Recently a new revision of IEC 61511 was released.

"As the standards come out and get applied, we see good things that come out of it; however, we also see areas where we might be able to improve those standards down the road," Statham added.

> "Safety shutdown systems continue to be a significant area of focus."
>
> —Shawn Statham, Emerson Automation Solutions

Current standards don't adequately address the integration of individual components in an SSDS. For example in an emergency shutdown (ESD) system, you typically have a valve from one manufacturer, an actuator from another manufacturer and controls from a third manufacturer.

"Most customers rely on best practices to guide the integration but everyone seems to be doing something different, communication in this field is also a challenge, and we often don't have the same taxonomy for that matter," he said.

For the upstream sector, Emerson is talking about high-integrity, pressure-protection systems (HIPPS) and ESD valves. "These two SIS subsystems are being applied in both drilling and production. HIPPS systems are applied in some overpressure cases where high pressure systems will potentially need to be brought to a safe state if there is an upset condition," Statham explained.

The SIS is comprised of sensors, logic solvers and final elements. The sensors measure temperature, pressure and flow, and act as initiators sending a signal through the logic solver. The logic solver then sends a signal to the automated valve package to open or close the valve. Companies like Emerson now manufacture all of these components. "There is potential for improvements to these systems as we begin to look at them more holistically and not as individual parts," he emphasized.

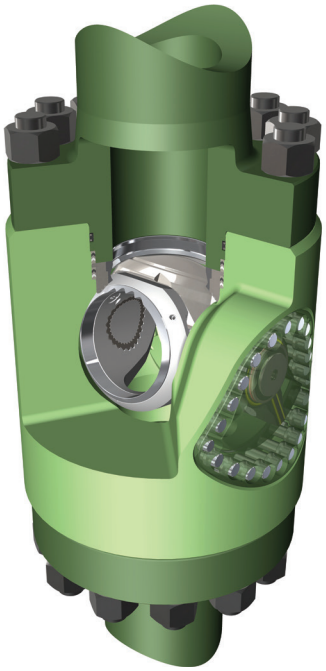
The automated valve also referred to as the final element often contributes the greatest portion of probability of failure on demand, and it's where the majority of failures occur. "This is largely due to the fact that the valve is a mechanical device and not instrumentation; it's in contact with the media and typically sitting static for long periods of time. The media can degradate the operational capability of the valve in many ways," he continued.

"It's critical that these valves be tested to ensure they can be counted on to work when we need them, and a full stroke test is not always possible due to process demands. Some of the more recent advancements we've made are in the area of partial stroke testing. Utilizing the Fisher Digital Valve Controller enables our customers to partially stroke a valve 5% to 10% to verify the valve moves, and the actuator and solenoid are working, etc. This test does not shut the process down while still allowing a test to ensure the system is functional," Statham said.

Another strong focus in the industry in general is the Internet of Things (IoT). "IoT offers new capabilities such as redundant monitoring of SSDS as well as remote diagnostics monitoring capabilities. The ability to perform partial and full-stroke testing on valves on an offshore platform via the internet and get all the diagnostic feed backremotely are areas where we're going to see more development in the future," Statham added.

In-riser 20,000-psi, HP/HT shear-seal valve

A new HP/HT in-riser shear and seal valve has been designed by Interventek Subsea Engineering. The



Interventek's Revolution Valve separates the cutting edge from the sealing surfaces. *(Image courtesy of Interventek)*

valve can withstand working pressures of 20,000 psi (20K) and temperatures of 350 F (177 C) for in-riser landing string systems. The Revolution Valve was designed for emerging HP/HT and deepwater well environments, particularly in the Gulf of Mexico, and is believed to be the first of its kind.

"The 20,000-psi valve was developed from our 15,000-psi form with very compact internal components and external rotary actuators. The simplicity of design makes it very eligible for fulfilling other configurations," said Gavin Cowie, managing director, Interventek.

The 20K in-riser valve is able to cut slickline, braided cable and coiled tubing up to 2 in. in diameter with wall thickness of 0.203 in. and 148-ksi tensile strength. The bore size is up to 5.125 in.

"The valve is utilized during installation and workover of wells completed with horizontal type christmas trees. The unique design is comprised of two elements. The first is a sealing flapper component, which is pivotally mounted to a second component—the structural saddle that allows the back and forth rotation," he explained.

"The saddle delivers the cutting forces and incorporates a hardened cutting insert. The primary sealing boundary is elastomer-free, relying instead on high-specification, resilient seals to contain produced fluids. It uses metallic sealing for the temperature piece of the system. The seals, like all the valve components, can be accessed for inspection or maintenance," he added.

"Conventional ball valves were never originally designed to be cutting tools. The same leading edge of the surface that is required to create a seal is now used as a cutting edge, so is vulnerable to damage and may not seal effectively," he said.

"In its Revolution Valve, Interventek separated its cutting edge from the sealing surfaces, so the sealing components are protected from damage cause by the cutting. After they have rotated past the shearing edge, the components are lifted into position to seal," he continued.

The external rotary actuators provide the required cutting force while keeping the hydraulics separate from the wellbore. The actuators are rated for 10,000-psi working pressure. The total fluid requirement for the actuator is 1.5 liters (0.4 gallons).

The new technology within the Revolution Valve allows it to be tailored to suit a variety of applications with different operating challenges, such as new subsea well development and heavy intervention from mobile floating drilling rigs using a drilling riser or BOP stack. It is also suitable for surface intervention, subsea in-riser completion installation and intervention, an open-water control package, exploration drilling program valves, abandonment tree saver valves and subsea lubricator valve assemblies. ■