Subsea choke valves meet Gulf of Mexico HPHT challenges

Tough operating conditions have required critical performance by subsea choke valves installed in deepwater, HPHT conditions at GOM development projects

Jeff Colbert, Master Flo Valve Inc., Edmonton

Extreme operating conditions have made subsea choke valves a critical element of success in high-pressure, high-temperature (HPHT) development operations in the Gulf of Mexico (GOM). Producing oil and gas from a reservoir at 19,000 ft (5,791 m) in 6,200 to 10,000 ft (1,890 to 3,048 m) of water is one hurdle. However, producing with equipment rated and qualified for 15,000 psi (1,034 bar) and 350°F (177° C) requires valve technology that has been creatively designed and rigorously tested, with safety and reliability on the top line of the engineer's task list.

In five recent GOM deepwater projects, the operator relied on specialty subsea choke valves supplied by Master Flo. "The ability of these hydraulically operated pressure control valves to meet stringent specifications and HPHT performance requirements was critical to the overall success of these development projects," said Master Flo President Mark McNeill.

Because these subsea choke valves are simple, fast, compact and lightweight, they allow for choke insert change-out without specialized lifting equipment or vessels. Built to 15,000-psi, HPHT deepwater standards, they are qualified to an 18,000-ft service depth.

BUILDING THE VALVE

The subsea valve is an HPHT, 15,000-psi insert-retrievable choke valve that is remotely operated and retrievable via a remotely operated vehicle (ROV). As an API material class HH valve, it is qualified to an 18,000-ft (5,486-m) service depth.

Intensive engineering work (under extreme time constraints) was required to produce a valve that meets these stringent specifications. The final product design drew on Master Flo's extensive experience in subsea operations to further advance this proven, ROV-assisted, insert-retrievable HRV choke technology. The company has been a participant in subsea supply and development since the late 1980s.

"We pride ourselves on the extensive R&D we put into our equipment to ensure the most reliable, cost-effective solution for our customers," said McNeill.

Over the years, the company has supplied many configurations and variations of chokes—from bolted-bonnet bridge chokes for Norwegian waters to diver-retrievable and ROV-retrievable insert chokes for the Gulf of Mexico and Brazil.

While the valve design's flexibility ensured adaptability of existing technology with regard to running tool usage and insert design, this still required a considerable amount of additional engineering work to design for the extreme temperature, pressure and water depth.

Design modifications to the actuator necessary to accommodate the deepwater environment included selection of bulk modulus and thermal expansion properties of the actuator lubricating oil to accommodate the deepwater application.

A second set of challenges involved designing a valve to meet the 15,000-psi/350°F project requirements. This produced a new set of obstacles that required extensive finite element analysis (FEA), including thermal FEA for heat dissipation.

To complete the equation, an API 6A HH material classification was added to ensure corrosion protection through superior CRA material selection. Testing included a million-step actuator cycle test, API 6A Appendix F and API 17D

testing for the choke, actuator and seals, coupled with erosion testing of the valve.

To ensure that qualification testing produced the expected results, extensive fixture testing preceded the assembly testing, which allowed the final test to act as a mere formality. "The true test for us was that all this engineering and testing had to occur in a timeframe that would allow delivery of the first two valves in 32 weeks," McNeill observed. "Technical risk assurance process meetings and good customer communication assisted in successfully building a truly reliable product that will be able to withstand the pressures on the front line of the GOM HPHT trees.

"We pride ourselves on being able to provide quality, specialized solutions to even the most stringent specifications, and our work on industry-leading GOM projects is an example of this commitment," he said.

TECHNOLOGY OVERVIEW

The subsea choke system developed for these projects is simple, fast, compact and lightweight technology that allows for choke insert change-out without specialized lifting equipment or vessels.

The system consists of three key components—the choke body, which becomes a part of the subsea tree assembly; the retrievable choke insert module, which includes the choke trim, all the wellbore seals, the ROV-operated clamp connector and actuator; and the choke insert running tool (CIRT).

To maximize service life, the choke uses Master Flo's cage and external sleeve trim. This patented trim design contains and controls the potentially destructive flow within the trim's tungsten carbide core, dissipating its energy before directing the flow through the valve outlet. The HRV choke trim is contained in a retrievable cartridge that uses the cartridge and internal sleeve to protect the valve body from abrasive properties of the fluid flow.

The choke insert is mated to the body with a segmented clamp operated via an ROV. The insert is guided into position with an external funnel, and it uses guide pins in the body to provide the final alignment. As the insert is clamped into position, the metal-to-metal body-to-bonnet seal is fully engaged and preloaded as the lower bean seal is installed. The clamping action also engages the hydraulic couplers in the bonnet and body that link the control system to the choke actuator. To complete installation of the insert, the ROV makes up a flying electrical lead to tie the choke position signal to the control system.

Choke actuation is accomplished with a subsea, stepping hydraulic actuator that is fully pressure-compensated and comes with a 4-mA-to-20-mA feedback position sensor and ROV-actuated manual override, and a visual position indicator.

The CIRT is deployed from a surface vessel, using a single down-line. The tool uses a passive, soft-landing system to control the speed at which the choke insert is lowered into the choke body. The ROV guides the CIRT into the funnel, engages the clamp and releases the insert. During retrieval operations, release of the clamp allows axial thrust from the body-to-bonnet main seal to disengage the lower bean seal from the body. This disengagement leaves the insert free and resting within the choke body to allow retrieval by the CIRT with no additional retraction forces. **CA**