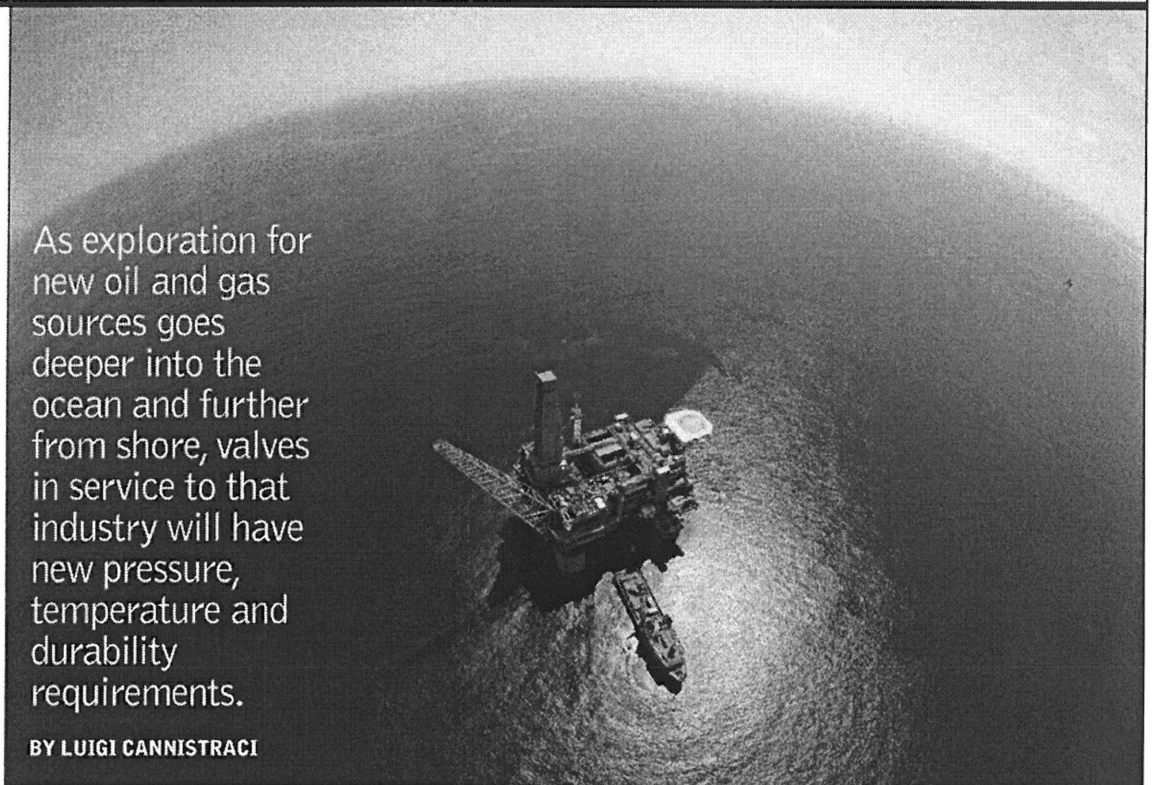
IN THE OCEANS' DEPTHS, VALVES FACE UNIQUE CHALLENGES



As exploration for new oil and gas sources goes deeper into the ocean and further from shore, valves in service to that industry will have new pressure, temperature and durability requirements.

BY LUIGI CANNISTRACI

Despite short-term reduction in exploration activity caused by the recent global recession, world energy demand continues to grow, which will fuel an explosion in offshore exploration over the next decade.

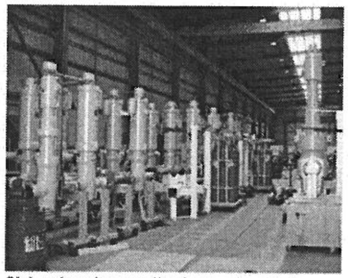
Deep and ultra-deep prospects will continue to eclipse mature shallow water hydrocarbon production, which has seen a decline in capital expenditures in recent years. Thanks to major technological improvements and deep water exploration and production successes, the definition of deep water has changed over the last decade—passing from a threshold of 200 meters to over 1,000 meters. What was considered deep 20 years ago is now considered shallow; and the greatest potential is now represented by fields located at depths of over 1,000 meters. In fact, most new projects under development today range between 1,000 and 2,000 meters. These deeper (than decades past) water projects—together with increased distances from shores and increasingly harsh environments—represent the next frontier in exploration, production and transmission. This deepwater shift also is driving technology changes across many subsea components, including risers, connectors, separators, pumps, inspections, umbilicals and valves.

As far as valves, many new challenges in the high-pressure, high-temperature subsea environment exist, including the need to develop special alloys, coatings, elastomers and thermoplastics that can withstand the rigors of ultra-deep operation. For subsea actuation, new forms of power sources are under development. In addition, challenges that impose further demands on technology have been added to the mix through harsh arctic environments (where large reserves potentially reside); through ice and ice load, through short intervention windows, and through zero pollution requirements and zero discharge regulations.

A UNIQUE CHALLENGE

One situation that differentiates subsea valves from even nuclear valves is the desire to meet zero maintenance for the life of the valve. This means an operating life of more than 25 years, and in some cases up to 50 years. When you consider that true subsea valves must operate in water depths of thousands of meters, far from shore, where maintenance is simply not possible, you understand why the design and manufacture of these valves is unique.

Add to that reality the fact that subsea valves will be in service in very sensitive environmental areas such as Barents and other Arctic seas, where a valve failure could cause a dramatic environmental impact, and you see why we must also add another mandatory requirement—zero risk of emission to the environment.



Slab gate valves are lined up and ready to go.

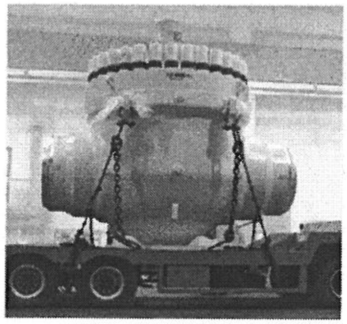
With the above criteria in mind, the essential design and manufacturing characteristics of a subsea valve require:

- Materials that are corrosion resistant (CRA), verified and tested during the whole process with mechanical features that meet or exceed limits of acceptability—documented and traceable at the highest level.
- Design verified with the most modern software and the most demanding criteria.
- Mechanical components created with the most advanced machine tools to achieve dimensional accuracy, tolerances and repeatability considered unattainable only a few decades ago.
- Cladding carried out by robotic processes to reach and guarantee the highest possible quality, ensuring life-long valve cycling without failure.
- Soft component materials, elastomers and thermoplastics selected and formed to the degree they do not introduce any element of failure risk. Rubber is the most common soft component for other types of valves, but because of the possibility of degradation through aging, rubber can't give the guarantee required for a valve that needs to be maintenance free. Soft sealing is used, but only as backup for the most precise and durable metal-to-metal primary sealing.

- Metal-to-metal seat-to-ball interface dynamic sealing by hard coating such as HVOF (high-velocity oxygen fuel). This is a significant factor in the reliability analysis.
- Once assembled and tested, a subsea valve has to pass a second level of demanding gas tests ensuring both safe and reliable operation of the valve before it's placed in service.

Before a valve design based on application is selected and used in the field, a valve prototype is submitted to a battery of tests that simulate the conditions the valve must withstand during the worst service situations and during the whole life of a valve in service. The valve must pass a combination of tests including pressure and temperature cycling, hyperbaric, endurance and pipeline installation dynamics such as bending.

Actuators, which are an integral component of subsea flow control, also differ in design requirements from surface applications. The subsea technology is not seen as valve plus actuator but as an integrated actuated-valve package. The actuators are currently either mechanical or hydraulic, though electric capability is just around the corner. Actuator reliability and longevity is as important as the valve itself.



This 42-inch Class 1500 subsea top entry ball valve was made for the Statoil Langeled pipeline, the world's longest underwater pipeline. The line brings natural gas to the United Kingdom.

As far as design, material selection, quality, testing and certification, the actuators have the same requirements as valves. Recently, different approaches to actuator design have been under investigation, which means earlier designs may need to be retrieved and eventually replaced. Ultra-deep hydraulic actuator pressures have been increased significantly to keep size manageable and umbilicals compact. However, innovations in electric actuator design may solve some reliability challenges at greater depths as well as current size and reaction time issues. In addition, electric actuators are considered more environmentally friendly.

TYPES OF SUBSEA VALVES

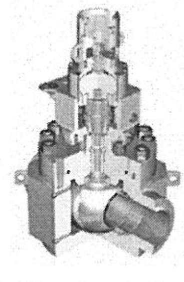
There are two types of on-off valves traditionally used for subsea applications: the slab gate valve, used mainly in manifold applications and the quarter-turn ball valve for flow lines: plems, plets and risers. Choke valves are used as regulating valves.

Slab gates are used mainly in the manifolds that collect the hydrocarbons from Christmas trees and transfer them to the flow lines. Slab gate valves in sizes up to 10 inches are preferable because they can be the most reliable in terms of sealing. They are also less sensitive to temperature variations. Slab gate valves can shut off a wellhead at the flow lines and are usually twinned for redundancy. Subsea slab gate valves are bubble tight, bidirectional and fully metal-to-metal sealing.

For severe service applications, the rising stem gate valve is preferred. Slab gate height increases significantly with size so ball valves are preferred for sizes above 10 inches.

Ball valves are the sole solution for on-off service for the flow lines where temperatures and pressures decrease and for sizes above 12 inches. Different designs such as side entry, top entry and fully welded ball valves are available to meet specific application requirements. The main difference when comparing surface applications is extensive use of heavy cladding on sealing and crevice areas. In the subsea design, careful attention is paid to the bearing selection. Other common subsea features include scrapers and guides as well as metal-to-metal sealing.

Used less extensively but no less important are check valves. In subsea applications, check valves usually require lock-open capability for pigging in both directions. For reverse pigging, the swing check valve is preferred. In some cases, check valves have been used as subsea isolation valves in very severe conditions such as those in the vertical position, under 10K of pressure and in depths of more than 2,000 meters. The check valve represents a relatively inexpensive, yet reliable control solution. Despite its design simplicity, prototype testing for check valves is no less stringent than for gate and ball valve prequalifications.



A top entry ball valve for subsea use.

CUSTOM ENGINEERED VALVES

Customized subsea valve designs include engineering variables that meet the application requirements. In fact, for subsea applications, customer standards prevail over (but are never less than) industry standards. Pressure class is often described as "special class," which means specific design for the field pressures. A customized subsea valve's specifications cannot be determined by off-the-shelf standards. A large bore subsea valve is frequently a "made-to-order" product, and the engineering process can be particular to one single valve.

To meet these stringent requirements for subsea valve customization, design and production, involvement of engineering at the preliminary stage of the project is critical. Front End Engineering Design (FEED) and pre-FEED studies require absolute attention from project participants to share experiences, concerns, suggestions and solutions. This is not the traditional buy/sell environment. Globally, only a handful of suppliers have the engineering resources and technological capabilities, experience and expertise to guarantee a lifetime service valve.

To qualify for subsea participation, these suppliers must possess the capability to meet some of the greatest engineering challenges. They also must have the ability to develop and manufacture using the highest levels of technology—from Computer Numerical Code (CNC) machine tools to robotic welding and testing areas such as the hyperbaric chamber in one valve manufacturer's facility that can simulate valve response in water depths up to 3,000 meters.

Technology such as this, together with engineers and personnel with specialized expertise and experience, is critical to production of any subsea equipment, including the valves that will spend their lifetimes far below the surface of the sea. VM

Luigi Cannistraci is international sales manager, Cameron Italy S.r.l.