Subsea valve actuation – reliability in depth

Fig 1 This spring-return rack and pinion actuator, model number GSR-2-490-110F/CX, will operate a 16 inch ANSI Class 900 ball valve installed on the eleven kilometre export pipeline from the Seth Platform off the coast of Egypt. This pipeline connects to the Tuna Platform export pipeline end manifold for onward transport to the shore via the TNW2 Platform. The actuator will operate an SSIV installed at a depth of 84 metres near to the Seth Platform, which, together with a check valve installed upstream of the ball valve, will prevent any gas backflow in the event of a pipeline or riser rupture in the proximity of the platform. The installation is very similar to the Rotork actuated SSIV package shown in Fig 2 that was previously supplied for the 24 inch export pipeline from the Tuna Platform. Both installations are equipped for pipeline pigging operations and fitted with superstructures for protection against accidental impacts and to prevent any interference with fishing activities.

Subsea valve actuation is an important part of Rotork's flow control activity. With an installed base dating from the early 1990s, operating at depths down to 2500 metres, Rotork Fluid Systems is familiar with supplying hydraulic actuator products to meet stringent subsea demands. Rotork's qualified engineering group has established a range of actuators with ROV (Remote Operated Vehicle) or diver operated facilities and developed some innovative solutions for specific subsea valve operations. A brief summary of valve applications using Rotork's actuators includes ESD (emergency shutdown), SSIV (subsea isolating), FPSO (floating production, storage and offloading), subsea manifolds and subsea buoys.

Special designs, special materials

Subsea valve applications, which usually involve vital failsafe and associated safety related duties, represent an area of technology demanding the very highest levels of quality and product integrity to ensure reliable long term performance.

Rotork has different types and configurations of actuators that are able to satisfy any specific customer requirement. One type of subsea actuator is the Rotork GSR/S hydraulic spring return unit, which is designed to provide a rotary quarter-turn movement and generally assembled in the spring-to-close configuration. Actuators are equipped with two hydraulic cylinders manufactured from specially treated material. This 'Quad' configuration creates a compact actuator with a balanced weight distribution. The seal package consists of a special PTFE based component that prevents sticking problems whilst guaranteeing low friction, high sensitivity and a long service life. Teflon sliding rings guide the piston in the cylinder and ensure a good radial loading capacity. The spring cartridges consist of a specifically welded container that houses a sub-frame assembled spring package. The system is designed to eliminate any risk of injury caused by spring disassembly. A rack and pinion mechanism transforms the linear movement of the hydraulic cylinders and the springs into a rotary movement for the operation of quarter turn valves, suiting the various ball valve designs that have been the predominant choice for subsea applications since the 1980s. The rack and pinion mechanism is made of alloy

Fig 2

Fig 3 A hydraulic actuator undergoing preparation for pressure testing in a hyperbaric chamber at the Rotork Fluid Systems factory

steel and is housed within a sealed centre body made of nodular cast iron, which protects against corrosion and guarantees personnel safety during operations. Stainless steel / PTFE bushings reduce friction and facilitate a long working life. The actuator is filled completely with a protective fluid and fully pressure compensated to allow operation at any depth.

Testing, testing…

For reliable performance in the subsea operating environment, the importance of testing cannot be over-emphasised, not only in order to prove the long-term performance and reliability of products, but also to gain specific approvals from end user markets without which it would be difficult or even impossible to bid on projects.
As with all major equipment manufacturers, Rotork's testing policies are designed to reassure the customer that the quality of its product range is first class through the achievement of internationally recognised quality assurance approvals for design and manufacture.
Running in parallel with these assessments, the company also subjects its products to the test procedures required for end user approvals in specific markets and industrial disciplines. In these areas there have been significant market-led increases in activity in recent years.
Rotork's in-house subsea hydraulic actuator testing activities have included two recent programmes, the first to achieve specific API (American Petroleum Institute) qualification and the second to achieve third-party witnessed hyperbaric approval to the international qualification procedure ST-028.
In the API test, a scotch-yoke hydraulic actuator with ROV override was operated in a hyperbaric chamber under an external pressure of 240bar-g to represent the submerged qualification depth of 2400 metres over a period of six weeks. The actuator was selected as a representative sample of all the company's subsea actuators for the purpose of the testing, which was witnessed by a third-party inspector.
The severity of the testing reflects the crucial nature of subsea actuator duties and the increasing depths at which actuators are expected to perform as exploration moves into new, more remote offshore fields.
In the ST-028 hyperbaric test a similar hydraulic actuator fitted with a limit switchbox was subjected to cyclic testing to prove its suitability for submerged installation. The witnessed testing included pressurising the switchbox without any sign of leakage, static torque and cycle testing of the actuator at ambient and external pressure, final static torque monitoring, strip down and inspection. This was a test amounting to over 2000 cycles, which is representative of a working life that is much longer than is generally required by international standards and specific application criteria.
In common with the stringent demands of all contracts involving subsea equipment, Rotork's engineering group has worked closely with contractor and end user engineers to meet specific project requirements. In this task the company can also draw upon the experience of an installed base of designs encompassing pressure compensated rack and pinion, scotch-yoke and linear actuators for both double-acting and spring-return duties, equipped with ROV and/or diver operated facilities.
Rotork Fluid Systems also shares a database with the Rotork Gears division, where a range of subsea gearboxes with diver or ROV operable overrides is manufactured.
The combination of products, engineering knowledge and test facilities provided by the two divisions provides a comprehensive subsea solution for both retrievable and non-retrievable applications. For example, ROV operated override options include the ability to fit adjustable extensions between the ISO torque tool receptacle (or 'bucket') and the override input drive shaft located on the actuator. This enables the receptacle to be remotely positioned from the actuator to facilitate ROV or diver access with the tool.

De-clutchable actuator with spool mounted gearbox

On retrievable applications such as some SSIV duties, one design option provides for interchangeability between the actuator and a ROV operated gearbox by means of transition spools and quick release methods. For total valve control this design has been further developed to provide the ability to de-clutch the actuator and remove it completely without affecting the valve position, whilst maintaining full local valve control by means of the gearbox.
Rotork has developed the de-clutch actuator system to provide complete flexibility for the operator. It has been specified for deep water applications including SSIV and other critical valve duties, including projects where the valve has been deployed separately from the actuator and when one actuator is required to operate more than a single valve installation.
In addition to the above, the functional and safety advantages of the de-clutch actuator include the simplification of actuator removal with associated cost

Fig 4 With the actuator removed in a simple lifting operation, the valve can still be operated by means of the ROV override on the spool piece (shown bottom left).

economies, the ability to fully stroke the actuator independently of the valve or commission the actuator without operating the valve, carry out a partial stroke test without risking valve closure and continue to operate the valve in the event of a hydraulic power failure.

How does it work?

The automatic clutch system consists of two coupling joints with a dog tooth mechanism, one assembled on the actuator and the other on the spool piece. When the coupling joint is engaged, the actuator can cycle the valve. When disengaged, the actuator can be stroked freely without cycling the valve. When the actuator is commissioned, the clutch is lowered into place. The actuator is fully stroked and automatically finds the correct position to engage with the valve. The valve can be operated by the ROV override on the spool piece if the actuator is removed or remains installed but disconnected from its remote power source.

Partial stroke testing

An important aspect of critical subsea valve applications is the ability to perform partial stroke testing, whereby the operation of the valve can be confirmed without fully closing it and interrupting the process. For fluid power actuators, a separate, dedicated technique is required to ensure the greatest security and reliability. The Rotork Smart Valve Monitoring (SVM) system incorporates several features that are not available from other systems, as well as providing detailed diagnostic data that allows the operator to plan for strategic preventative maintenance. The key to the SVM's reliable performance is its total separation from the valve's control system, which enables the operator to design the control system exactly to suit the routine and safety requirements without having to compromise for the testing programme.

The SVM control system is connected to the power supply to the actuator's solenoid valve. The monitoring function is then provided by a pressure transmitter located between the solenoid valve and actuator which records the instrument pressure changes whilst the valve is moving. Any change in the valve performance is detected and identified by a change in the pressure wave exiting the actuator. The simple, self-contained design of the SVM enables it to be used with the most complex control mechanisms and makes it impossible for the SVM to prevent the valve from closing on demand. The SVM always tests every final element component of the shutdown system and is therefore capable of detecting all the failure modes of the valve, actuator and controls that are possible during a partial stroke test. It is designed to ensure that operators obtain the maximum safety performance from their systems whilst running their plants at maximum efficiency.

Fig 5 Cabinet-mounted Rotork SVM units. The integrated computer enables the operator to analyse partial stroke testing data and diagnose potential issues.

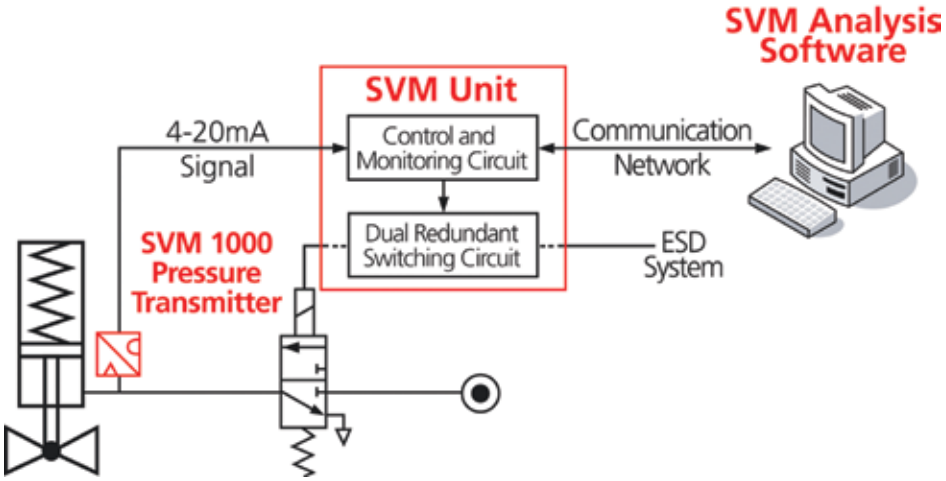

Fig 6 A basic configuration diagram of a SVM installation, illustrating how the installation is separate and independent from the valve control system.