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Skid integrators get to grips with tubing challenge

Integrators charged with building chemical injection skids for medium-pressure applications face some formidable obstacles. Two of the chief obstacles concern critical fluid system components: medium-pressure instrument ball valves and reliable end connections for use with SAF 2507 tubing. Swagelok's **Bill Menz** and AGI Packaged Pump Systems' **Tony Taylor** discuss.

Under certain circumstances, instrument ball valves in the medium-pressure range are known to leak across the seat. After sealing at high pressure, they may have difficulty resealing at low pressure, especially if pressure in the system is being built up slowly.

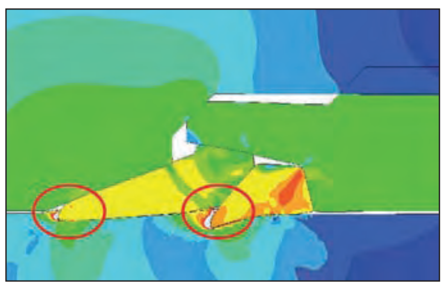
End connections for the valves pose a special challenge when the tubing required is made of SAF 2507, a corrosion-resistant material preferred in many aggressive chloride-containing environments.

Until recently, the market has not provided simple, easy-to-use, mechanical grip-type tube fittings for SAF 2507 tubing at pressures up to 15,000psig. For such applications, the industry has relied on cone and thread fittings, which can be temperamental and difficult to fit and assemble.

About the authors

Bill Menz is manager, field engineering at Swagelok Company, leading a team of engineers dedicated to supporting application, service and training of Swagelok products. Since joining the company in 2002, he has worked closely with distributors and end users to define market trends, growth opportunities, new product needs, and applications for its analytical and process instrumentation products.

Tony Taylor is design and special projects manager for AGI Packaged Pump Systems. For 28 years, he has been involved in the design and fabrication of oil field products at AGI, including pipeline packages, chemical injection systems, and systems with pumps.



FEA shows how the front and back ferrule grip the tubing on a medium-pressure Swagelok tube fitting rated for use with SAF 2507 tubing.

AGI beta tests a new valve

As an integrator that has built skids for most of the major oil companies, AGI Packaged Pump Systems was acutely aware of the challenges concerning medium-pressure instrument ball valves and end connections for SAF 2507 tubing.

Therefore, when it accepted a contract to build two medium-pressure skids with SAF 2507 tubing – a chemical injection skid and a methanol injection skid – AGI looked for a company that could provide new solutions.

Swagelok had developed – but not yet released – the FKB series medium-pressure ball valve, employing a new technology that would enable the valve to seal and reseal reliably across the entire pressure range up to 15,000psig.

Offering to beta test the valve, AGI built a testing fixture designed to put the valve through a rigorous set of cycles simulating conditions on a methanol injection skid for deep water exploration. The test employed methanol as the fluid medium and involved using a small pneumatic pump to slowly build pressure to 15,000psig on a closed FKB series medium-pressure ball valve; opening the valve and releasing the pressure to the atmosphere, closing the valve and repeating the process.

AGI planned to cycle the test valve until failure. The test ran for two and a half days, with the valve completing over 4000 cycles without failure. At that point, AGI was satisfied with the performance and stopped the test. Over the 20-year life of a chemical injection skid, an instrument ball valve is typically cycled 300 times, about once per month.

The challenges concerning medium-pressure ball valves apply to other oil and gas applications as well. In wellhead control panels, workover vessels or workover panels, medium-pressure ball valves are used to deliver hydraulic pressure to the large wellhead safety shutoff valves at the subsea wellhead. Pressures up to 15,000psig are required because of the depth of the wells. Medium-pressure ball valves are also used on hydraulic power units, where hydraulic pressure for platform utilities is maintained. In all of these applications, leakage is a serious issue. The substances under pressure are often flammable.

Finding the right connection

Integrators are frequently under very tight time constraints when they are building skids for platforms. The project may be behind schedule even before the fabrication begins. Therefore, efficient component assembly is critical to keep a project moving.

Cone and thread fittings are time consuming to assemble. Any imperfection in the cone or the nipple increases the likelihood of a leak. Concerns about quality have led some owner companies to require that the nipples be purchased from the factory rather than be made

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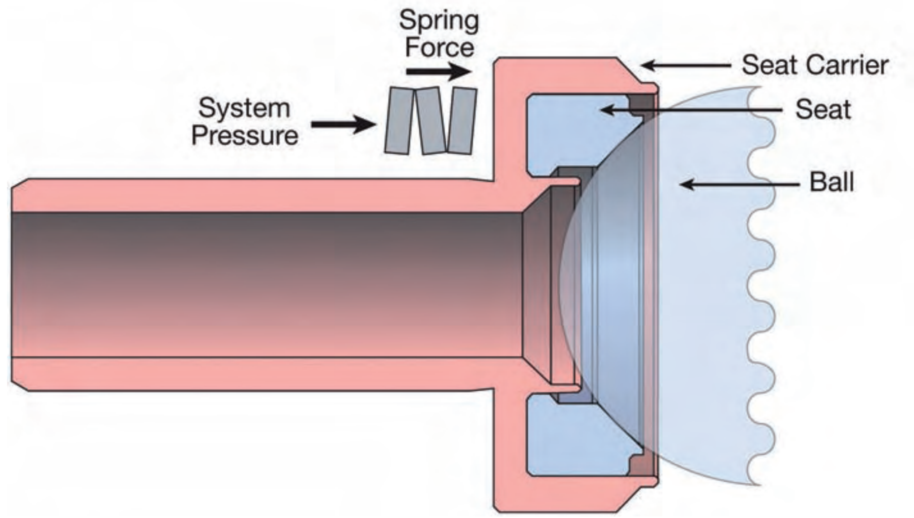
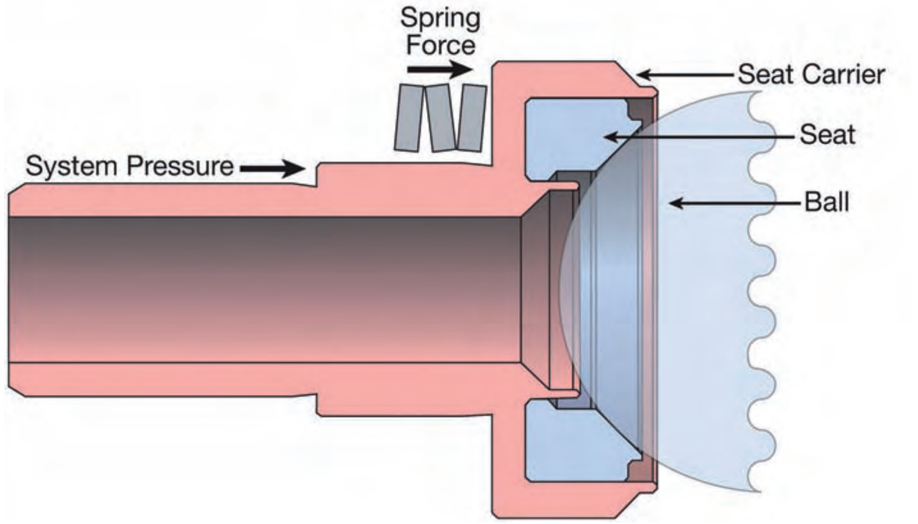


A conventionally designed live-loaded ball valve in which the spring force and the system pressure are arranged in series, one behind the other. The system pressure acts on an o-ring and backup ring directly behind the springs, which, in turn, act on the seat carrier. As pressure increases, system pressure will collapse the springs, canceling out their force.



The FKB series valve design, in which the seat carrier is stepped, enabling the springs and the system pressure to act at different points on the seat carrier. Each force counts, regardless of its relative value. System pressure will not collapse the springs.

onsite. If the tubing length turns out to be short, a new piece must be ordered, resulting in a delay.

Integrators are also concerned about vibration. A fitting must hold up under vibration, not only during operation on the platform but also during transport to the platform.

AGI found a solution in Swagelok's mechanical grip tube fitting rated for medium-pressure connections to SAF 2507 tubing. The fitting contains two ferrules. Both the front and back ferrules grip the tube during installation. This robust grip allows for working pressures up to 15,000psig.

SAF 2507 is considerably harder than 300 series stainless steels, with a Rockwell C hardness of up to 32 (HV 318), as compared to AISI 316 and 304 stainless steels, which have a Rockwell B hardness of 90 or less (HV 185).

The stainless steel ferrules on the tube fitting are able to grip even SAF 2507 tubing because they are fully case hardened with the SAT12 service, a patented, low-temperature carburization process. Surface hardness of the treated ferrules measures 1200 Vickers – which is comparable to tool steel, or about three times harder than untreated stainless steel.

This carburization process preserves the ductility of the stainless steel even as it hardens it. The ductility of the back ferrule enables it to hinge downward onto the tubing, creating a grip on the tubing over a large surface area. This grip helps to protect the fitting from vibratory stress.

The result is a tube fitting that can be assembled easily and tightened with simple tools. No electronic swaging unit is required. The connection can be taken apart and remade a number of times. The medium-pressure tube fitting can be checked positively for sufficient pull-up at initial installation with a handheld gauge, a calibrated flat piece of steel that checks for the right distance between the nut and the body of the fitting.

New ball valve design

AGI's beta test of the FKB series medium-pressure ball valve demonstrated that the valve reliably and repeatedly seals over the entire pressure range up to 15,000psig. The valve's effectiveness may be attributed to a special type of patent-pending live-loading technology termed 'direct loading'.

A ball valve seals because of contact pressure between the ball and the seats. One of the principal challenges in designing a ball valve is determining how to generate sufficient force to create this contact pressure. If the force is too little at any point in the pressure range, the valve will leak. If it is too great, the valve will be difficult to actuate and its cycle life may be compromised.

Live-loading is one means of applying force. Live-loading refers to a spring that fits somewhere between the end screw and the seat. Usually, the spring pushes against a seat carrier, which is a device that holds and positions the seat for ideal contact with the ball. Live-loading is especially important for three-way valves where the sealing force is provided solely by the upstream seat.

Another source of sealing force is system pressure itself. Valves that are not live-loaded may rely entirely on system pressure to generate the force between the ball and the downstream seat. In this case, sealing force may be adequate at the upper pressure range, but inadequate in the lower pressure range. Once the seat has become compacted – or 'taken a set' – at high pressure, resealing at lower pressures may be difficult. The seat material may not have enough memory to return to its original shape. Therefore, with low system pressure and no springs, there may not be enough force to make the seal.

Under such circumstances, a technician may crank the end screws tighter to prevent leakage. This action may correct the immediate problem but with an unintended result: Actuation will

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LEFT: *The chemical injection skid fabricated by AGI Packaged Pump Systems.*

RIGHT: *The FKB series medium-pressure ball valve installed on the chemical injection skid.*

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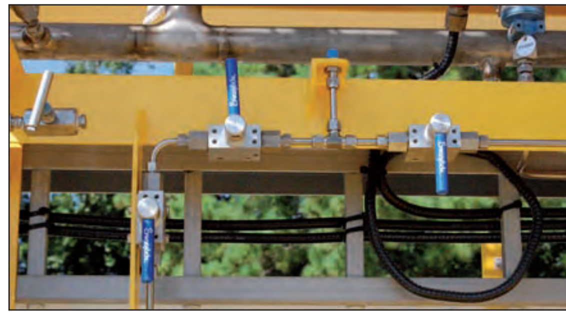

be difficult, especially at high pressure. As a result, to actuate the valve at high pressure, the technician may need to use a 'cheater bar', a bar that extends the handle's length enabling greater leverage.

Even in the case of a conventionally designed, live-loaded ball valve, there may be issues with the seal at the lower end of the pressure range (<5000psig). The valve may create good sealing force initially because of the force delivered by the springs. But as the system pressure overcomes the springs – and collapses them – the sealing force may not be sufficient. When system pressure and the springs are arranged to act in series – one behind the other – there is no net sealing benefit at certain points in the pressure range.

By contrast, in the FKB series medium-pressure valve, these two forces – system pressure and the springs – act on separate points on the seat carrier. Therefore, both contribute to the overall net sealing force. In the FKB design, system pressure on the upstream side acts on one step in the seat carrier, while the springs act on a second step. Together, they create a combined force adequate for sealing across the entire pressure range. This type of live-loading is termed 'direct loading'.

An additional design challenge for medium-pressure valves concerns handle orientation. In some cases, adjacent components may prevent the quarter-turn handle from being fully actuated. The challenge is to create a handle that can be repositioned in any one of four quadrants so a technician can reposition it without having to remove the valve and modify the valve supports.

This goal is achieved by introducing a stop plate between the handle and the valve body. The stop plate may be repositioned, shifting the on and off position by 90° increments.

Final testing

On the two skids that AGI fabricated, there were 36 valves and 452 medium-pressure tube fittings or end connections for use with SAF 2507. AGI checked all fittings with the handheld Swagelok gauge. Capital Valve & Fitting, the Swagelok authorized sales and service center in Baton Rouge, Louisiana, also checked the fittings, and found them all to be pulled up and tightened properly.

As part of its normal testing process, AGI tests all skids before shipping by cycling valves and pressurizing the system to its full-rated pressure. In this case, the skids showed no leaks anywhere, including at end connections or across the seat of the ball valves. In past tests for other skids, AGI has spent as much as four hours correcting leaks. For example, in one case, the skid contained more than 100 valves, and the seats on each one had to be replaced. The initial pressurization of the system had compacted the seats and therefore the valves could not reseal as pressure in the system was being built back up.

The FKB series ball valve and medium-pressure end connections saved AGI considerable time and costs during the initial fabrication and at final testing. When a component is dependable and easy to use, there is a quantifiable savings in avoided guesswork, setbacks, reconfigurations, failed tests, and delays resulting from special tools that are not readily available or parts that need to be reordered and refitted. Additional savings are realized by the end user in reduced maintenance costs and ease of service throughout the life of the skid. Total cost of ownership over time – as opposed to the initial purchase price of a component – is the appropriate frame of reference when comparing costs.

The two new skids that AGI successfully fabricated with medium-pressure ball valves and end connections for use with SAF 2507 tubing are in service on platforms in the Gulf of Mexico. **OE**

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