The Insider's Guide To Applying Miniature Solenoid Valves

A White Paper From ASCO Valve, Inc.

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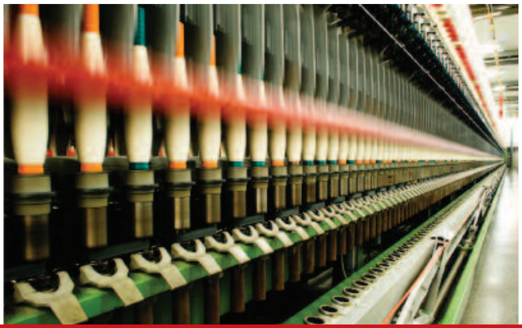

Too many compromises?

Equipment designers frequently must incorporate miniature solenoid valves into their pneumatic designs. These valves are important components of medical devices and instrumentation as well as environmental, analytical, and similar product applications.

However, all too often, designers find themselves frustrated. They face compromise after compromise. Pressure for increasingly miniaturized devices complicates every step of the design and valve selection process. And missteps can wreak havoc. How do designers balance the needs for reliability, extended service life, and standards compliance against often-contradictory performance requirements such as light weight, high flow, and optimum power use?

This report consolidates the expert views of designers and manufacturers with wide experience applying miniature solenoid valves for myriad uses across multiple industries. It presents a true insider's guide to which requirements are critical for common applications. It also highlights new valve technologies that may lessen or eliminate those troubling compromises.

1 Ensuring reliability and repeatability

When it comes to a miniature solenoid valve, most designers' fondest wish is to "spec it and forget it." So the ability to perform the job properly — and to repeat that performance time after time, without unwanted variation — looms large in their valve choices.

For instance, in carpet manufacturing, a tufting machine may employ up to 1200 miniature valves. Driven by air power, each valve/cylinder assembly must thread a single yarn repeatedly through the carpet backing, ultimately producing a length of carpeting 12 feet wide. However, if even one valve doesn't perform to specification, the process instead produces a carpet where one long line of thread is not tufted through. Result: instant carpeting scrap.

In the medical devices industry, a portable oxygen concentrator that fails to deliver the required amount of oxygen may threaten a patient's health. Even earlier in the development process, consequences may still be serious. The further into the design project a reliability issue is discovered, the more expensive it becomes. When a valve design, type, or manufacturer is changed, regulators mandate that testing must start all over again.

To avert such problems, experienced designers choose valve manufacturers with established reputations for high reliability. They also pay attention to anything they can learn about valve manufacturing processes, quality control measures, and so on.

Valve designs can also impact reliability. For instance, in some analytical or test equipment, valves come into contact with a mixture of gases. However, most miniature solenoid valves are constructed with internal elastomers that can swell on contact with such gases. If the valve design can't compensate, over time the swelling can change performance parameters. It may even render the valve inoperable, so that what starts as a repeatability problem becomes a critical fault — bringing the entire device to a halt.

Smart designers with concerns about reliability consider the extent of a valve's resistance to performance changes due to chemical and/or compatibility effects.

2 Reaching for longer life

A valve with longer service life is desirable in most applications, and critical in some. For instance, in medical applications and any high-cycle operation, even long-term failures must be held to an absolute minimum. Frequent maintenance and valve change-outs are also to be avoided whenever possible. Long-rated life can also be a good indicator of greater general durability in rough or challenging applications.

However, sufficient longevity can prove difficult to attain. Insiders warn of one particular challenge: breakdown of the dynamic seal.

Every time a valve operates, the poppet seats and unseats from the sealing surface. Over millions of cycles, the poppet simply wears down. Most valves encounter this mechanical wear issue in a number of applications; a few manufacturers use innovative poppet designs to counteract wear.

Experienced engineers with applications that necessitate longer cycle life may also consider plastic-bodied designs. These often offer a smoother surface finish and less friction than metal-bodied valves, which reduce poppet wear.

Ratings are dependent on conditions such as the media selected, the length of time the valve is energized, the limits at which it's used, and other factors that vary widely for each application. Broadly, most makers rate their valves for tens of millions of cycles. However, alert designers may now find products rated at hundreds of millions of cycles.

3 Looking for lighter weight

Practically every new device design must achieve more miniaturization than the one before. This puts a premium on decreasing the weight of every component.

Low weight is particularly critical in portable devices, where every ounce (or gram) counts. A decrease in valve mass allows savvy designers to increase battery mass for more power or longer run time.

In medical devices, lighter weight may even have regulatory implications. In the U.S., for example, to allow Medicaid reimbursement for the portable oxygen generator mentioned earlier, it must total no more than 10 pounds. Since each generator contains multiple miniature solenoid valves, valve weight becomes crucial in the overall design.

Older valves can be slightly larger than more modern models. Designers may find that giving priority to even a small decrease in weight or envelope dimension can make a large difference in how easily the valve works within a constrained design.

Many traditional valves are still made of materials such as stainless steel. New plastic bodies can achieve significantly lighter totals.

Unfortunately, attaining higher flows or lower power consumption can both add to valve weight. Experienced designers seek out innovative valve designs that find new ways to balance these considerations with acceptable weight reductions.

4 Achieving higher flow rates

As miniaturization continues, everybody's looking to optimize performance in ever-smaller designs. Increasing the airflow rate of a miniature solenoid valve can become an important step.

However, a delicate balance exists in a miniature valve design between power, pressure, and flow. To achieve higher flow rates, overall power consumption and pressure ratings must be reviewed to ensure customers' expectations are achieved.

Savvy designers know that even an incremental boost in flow rate can make a measurable performance difference. For example, air bladder systems used to elevate hospital beds may use higher-flow valves to operate in 8 seconds instead of 10. This may have a surprising impact on alleviating patient discomfort and saving staff time.

Unfortunately, orifice issues may complicate valve selection. For instance, some valves present excessive sensitivity to port alignment due to unsymmetrical port layout when manifold-mounted, which can have an adverse effect on flow.

As always, the designer must perform a balancing act. High flows require the largest possible valve orifice, but demand higher valve power and, often, larger valves. Discerning designers seek out modern valve designs that are more efficient and achieve higher flows while still maintaining relatively light weight and small size.

5 Opting for optimized power performance

Efficient energy use is of particular concern in portable devices operated by battery power. An excellent miniature solenoid valve should offer superior optimization of power at the same or lower valve weight, to make the most out of every amp-hour of energy a battery can generate.

However, some valves still on the market suffer from power-hungry performance. Many of these attempt to compensate by adding a pulse-width modulation (PWM) circuit. This solution reduces overall power consumption while maintaining holding current. But it also adds considerable expense.

Designers with the inside track on the latest innovations look for features such as low-watt, more efficiently designed coils. Valves with these advantages may help extend battery life or increase battery size and device performance.

6 Complying with changing standards

As standards evolve, designs — and designers — must change to meet them.

For miniature solenoid valves, the most important recent changes are the Reductions of Hazardous Substances (RoHS) requirements. These mandate manufacture of new electronic components without use of lead or other restricted materials. RoHS is a European Union requirement, but U.S. manufacturers wishing to sell into the EU are anxious to meet it. Insiders are also keeping a close eye on an even newer development: the Registration, Evaluation, Authorization, and restriction of CHemical substances (REACH) standards currently being finalized in the EU.

Approvals from standards agencies such as CE, UL, UR, and CSA may also be required for valves in particular designs. Obtaining these for specified valves must often be negotiated with the manufacturer.

For miniature solenoid valves, even today, most manufacturers only offer RoHS or other compliances on a few premium versions. Knowledgeable designers make certain that the necessary compliances have been met for any valve they consider.

Flexible technologies equal fewer compromises

To overcome application challenges and reduce or eliminate the need for undesirable compromises, designers with experience and insider knowledge are turning to a new category of technological solutions.

These include line-mounted or manifold-mounted styles capable of precision control of today's demanding pneumatic systems. Miniature solenoid valves, such as ASCO's new 411 Series, have the capability to minimize tradeoffs and compromises — representing a whole series of evolutionary improvements over traditional valve designs.

Design engineers tired of tradeoffs report that this new technology gives them more options and a bigger envelope of operating characteristics. Simply put, these valves work — often as closely as possible to the limits of real-world valve physics — to meet the widest spectrum of previously contradictory needs in a single valve.

Reliable and repeatable. The new miniature solenoid valve technology delivers dependable, consistent performance that outstrips conventional models. The valves represent significant improvements in a number of characteristics for environmental controls, medical devices, pharmaceutical, analytical, scientific, marking/labeling, instrumentation, and textile industries, as well as for gas analyzers, clinical diagnostic equipment, gas chromatographs, and dental equipment.

Longer service life. According to the specifics of a given application, these valves can deliver, hundreds of millions of cycles in normal operating conditions. At more than twice the rated life of conventional valves, that's a best-in-class achievement. For example, the ASCO technology has a unique plunger design that utilizes a spring-loaded arrangement that absorbs seating shock, protecting the poppet from undue wear. This design also compensates for elastomer swelling, since the spring takes up any compression without changing the overall plunger length. The new technology minimizes the dynamic seal breakdowns and heat- or chemical-induced performance disruptions that plague other valves.

Lightweight. Despite all its performance advantages, at only 50 grams, the new 411 Series plastic body model offers up to 15% less weight than many other valves in its class. Thus the technology meets ongoing calls for less weight, especially in portable devices. Finally, with a smaller size than some other valves, the new technology is suitable for the tight footprint that a number of miniaturized designs demand.

Higher flows. Up to 15% greater flow rates and higher maximum operating pressure differentials (MOPDs) can be achieved in these new valves, depending on application. The 411 Series manifold mount version incorporates slotted ports to improve flow efficiency. This feature eliminates restrictions due to port misalignment during installation. With these enhancements, engineers can design products with greater operating speeds, higher pressures, and smaller volumes. This delivers noticeably improved performance for today's critical miniature valve applications.

Optimized power performance. Users report these new valves offer better performance at the same power consumption as previous models. Contributing factors include a more efficient coil, plus innovations in the design of the valve's body, porting, and plunger. All work together to provide optimum operation at rated power. They also eliminate the expense of added PWM circuitry. Designers can get better battery performance or life, as their application dictates.

Full standards compliance. These new valves offer RoHS compliance across the entire miniature solenoid valve product line. They also meet CE directives. To ensure better compliance with almost any quality standard, they are manufactured and tested exclusively in an ISO Class 8-equivalent controlled-environment clean room built and dedicated to this technology.

Conclusion

Selecting miniature solenoid valves for the design of a given device usually involves finely balancing tradeoffs among competing pressures for reliability, service life, light weight, higher flow, optimized power use, standards compliance, and more. Fortunately, newer technologies have reduced the compromises — while increasing the performance. New miniature solenoid valve technologies represent the fusion of several innovative approaches to meet the widest possible range of demands from knowledgeable designers across multiple industries.

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