FASTER AND SMARTER VALVE POSITIONERS

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TWO SIGNIFICANT IMPROVEMENTS IN CONTROL VALVE POSITIONERS MEET THE DEMANDS FOR HIGHER PERFORMANCE OF THE CONTROL VALVE AND THE CONTROL LOOP. ONE OFFERS AN INCREASE IN GAIN, SENSITIVITY, AND SPEED OF RESPONSE OF AMPLIFYING RELAYS. THE OTHER USES SMART POSITIONERS FOR TWO-WAY COMMUNICATION WITH THE DISTRIBUTED CONTROL SYSTEM PROVIDING VALVE DIAGNOSTICS, ALARMS, ERROR CODES, AND PREVENTIVE MAINTENANCE DATA.

DURING THE PAST 15 YEARS, DEVELOPMENTS IN digital controls and instruments diverted attention from the final control element—control valves. The general perception was that they were simply engineered obstructions in the pipeline designed to absorb energy. They were engineered commodities and not the critical third instrument in the control loop. The result was that users denied themselves the full benefits of digital control. The performance of their control valves limited their control capability. An analogy might be buying a Corvette and having the dealer install a speed control governor limiting the vehicle to 80 mph.

The lack of an industry standard of comparison for different brands often frustrated efforts to use higher-performance valves. Control valves usually had descriptions as good, very good, or simply the best valve in the world. Such descriptors are ambiguous and of questionable value in the selection process.

A new selection tool became available in the last decade with the publication and recognition of a benchmark standard that included specific, measurable values. For the first time, users had a measurable performance standard with which to compare different control valves. While some controversy still surrounds the specific values, people often overlook the important fact that there is a standard to discuss. Satisfying an important need, these standards will eventually undergo refinement to everyone's general satisfaction. They will give users an invaluable selection tool and give designers a measurable goal to drive their designs.

THE PERFECT POSITIONER

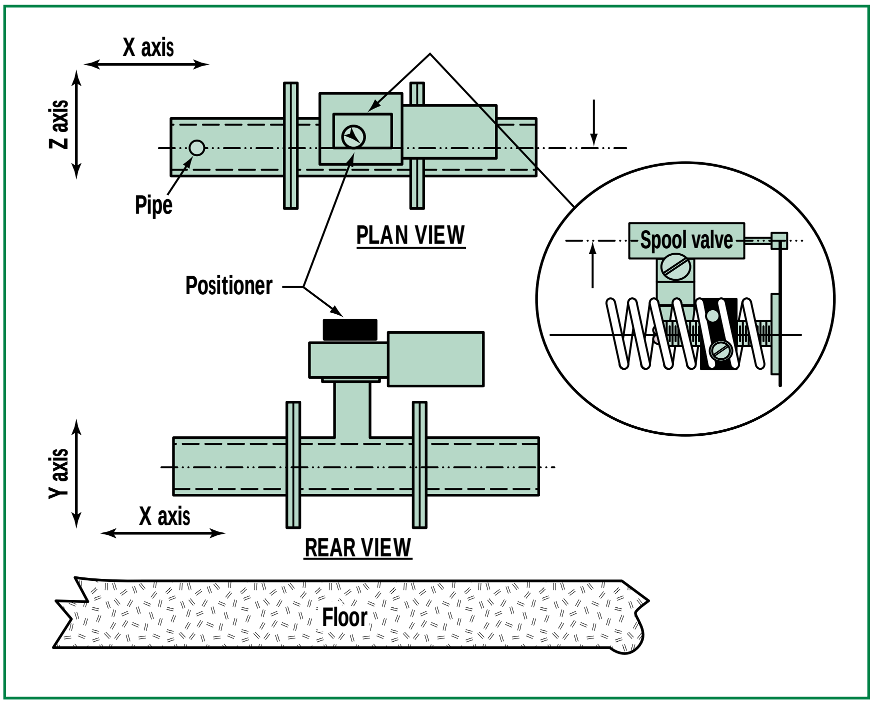
With industry's unprecedented attention on the control valve, several manufacturers began improving their valve performance by minimizing backlash, friction, and overshoot. They also improved speed, accuracy, and dead time. Clearly, mechanical valve and actuator improvements would have limitations without also improving the valve positioner. This would result in a new generation of high-performance valve positioners.

How good is this new generation? What characteristics would the perfect positioner have? From the users' standpoint, the following are some common requests heard in the field:

- Cost no more than US$ 200;
- Work reliably on a semi-hydraulic air-supply slurry containing rust, dirt, wasp nests, and other foreign articles;
- Self-calibrating, auto-tuning, and requiring only operator initiation of the procedure
- Self-diagnostic to advise operators of the year, date, and hour it was intending to fail;
- Self-monitoring to alert operators only when exceeding a pre-selected operational value;
- Reliable while strapped into an operating paint shaker, and able to survive a 500-ft drop onto concrete;
- Adjustable air delivery and gain without decreasing sensitivity;
- Twice as accurate and repeatable as process transmitters;
- Incapable of improper installation; and
- Function in 240°F ambient temperature.

	PERFORMANCE SPECIFICATION				
	T_d L.2s	T63L.6s	T98L1.4s	Overshort < 20%	Accuracy < 1%
Test 4	0.16 s	0.27 s	0.69 s	5%	0.12%
Test 2	0.17 s	0.25 s	0.48 s	15%	0.10%
Test 1	0.12 s	0.30 s	0.60 s	5%	0.10%

I. Valve response



1. Installation with orientation of the spool valve along the axis of minimum pipeline vibration amplitude

While some listed items may seem humorous and unreasonable today, travel to the moon was also unreasonable 50 years ago. The following is a review of several new design improvements that move toward satisfying the ideals.

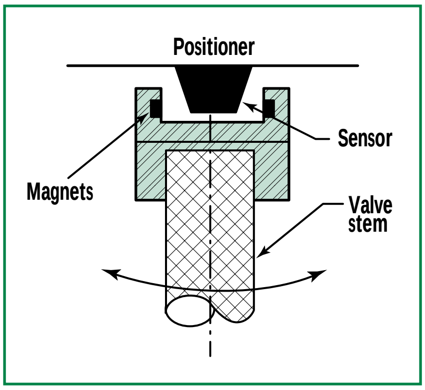
OLD TECHNOLOGY

New designs promise to overcome the limitations of so-called spool valve positioners—the most popular type in use today. While new technologies require time to prove their long-term reliability in service, so-called old technology has already proven itself in service and demonstrated the ability to satisfy the most stringent performance standards. **Table I** shows an example of the valve response achieved with an improved version of a 20-year-old design electro-pneumatic positioner.

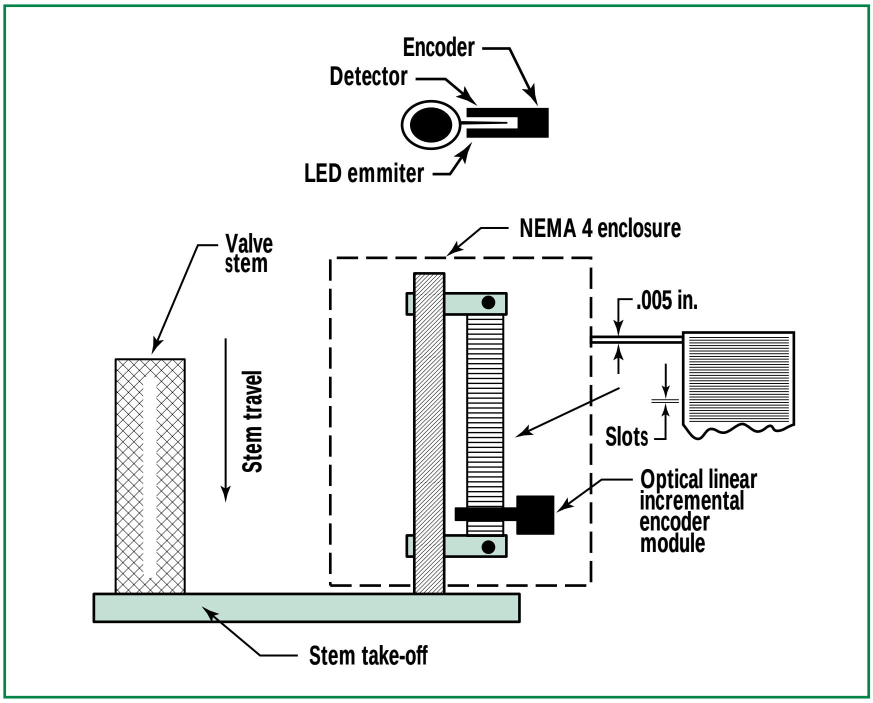
Testing conducted with this improved positioner and three leading brands of a v-port control valve with an actuator gave dramatically improved performance of the assembly. It exceeded suggested standards by a large margin. State-of-the-art technology deserves important consideration today for the unique benefits it can provide:

- Performance: Many units can exceed existing standards. Air delivery volumes have increased up to 60%, and pressure gain has increased from 6–800 to a phenomenal 1800:1. This is adjustable and improves narrow-band control speed and accuracy.
- Cost: The cost is only a fraction higher than previous designs.
- Conversion costs: Conversions are economical as they retrofit to existing brackets and feedback linkages.
- Familiarity: They require little, if any, technician re-training for installation, trouble shooting, and maintenance.
- Predictability: With no change in its basic design, users know what to expect and the limitations of this technology.
- Value: The units provide a high-performance, economical, long-term transition from analog to fully digital positioners.
- Instrument air quality: Historically the nemesis of all electro-pneumatic instruments, one must consider that new technologies have yet to prove their reliability and tolerance to water, oil, and dirt after years in service.
- Vibration resistance: Rapid oscillations of the spool with consequent galling, sticking, and failure of the spool valve are the leading modes of failure caused by pipeline and valve vibration.

Minimization or elimination of vibration is possible by changing the installation orientation to that shown in **Fig. 1**. This shows orientation of the spool valve along the axis of minimum pipeline vibration amplitude. The maximum amplitudes of the pipeline vibration are usually in two directions—up and down and side to side (Y axis



2. Magnetic, nonmechanical feedback between actuator and positioner



3. Integral optical encoder to measure valve stem position

and Z axis). The pipe does not stretch and contract (vibrate) along the X axis. Aligning the spool parallel to the longitudinal axis will minimize or eliminate spool oscillations and resultant premature failure.

DESIGN INNOVATIONS

Positioner and actuator misalignment

Installation and accurate alignment of the positioner spindle to the actuator are critical to minimize friction, dead time, and accuracy. As **Fig. 2** shows, one manufacturer has addressed this issue by using a magnetic nonmechanical feedback between actuator and positioner.

A noncontact magnetic coupling using the Hall Effect principle accomplishes the valve position feedback to the positioner. The promise of this technology is to provide consistently accurate performance by eliminating the need for linkages, levers, and connecting rods. Performance on mechanical feedback positioners will improve with proper installation procedures. The positioner shaft should first connect to the actuator coupling. One should then check the mounting bracket mounting holes for proper alignment. If misaligned, installers often force the bracket into position using the mounting bolts. This procedure introduces side loading of the positioner spindle, increasing the spindle- to-bushing friction. Side loading can cause sticking and can degrade the accuracy and dead time of the valve assembly with premature degradation of performance and guide bushing failure on the positioner. When necessary, adjust or shim mounting brackets rather than forcing them into position.

Air bleed and dirt tolerance

A cliché states that dirty instrument air is cheap, and good quality air is expensive. This is more true than ever due to higher energy costs. Manufacturers have responded with “low bleed” positioners. Users have historically had to compromise air bleed to achieve reliability.

To reduce air bleed off the spool valve, manufacturers had to minimize spool tolerances to a few microns. This then required the installation and proactive maintenance of 3–5 µm coalescing filters to ensure reliable operation. One manufacturer’s solution improves dirt tolerance dramatically by using pulsing solenoids to load and vent actuator air. Sealing of the coils in the solenoids allows them to control water. The rapid opening and closing of their 0.060-in. orifice allows use of coarse filters without clogging the positioner. As the solenoid’s power requirements dictate a three-wire instrument, other manufacturers designed low power piezo-electric pulsing valves in a two-stage design. This allows loop powering of the positioner at the sacrifice of air volume delivery. Both situations offer zero-bleed at steady-state conditions. This is an important economic consideration for areas having a limited air supply volume.

The other alternative to improving reliability uses high bleed positioners—looser spool tolerances. An accurate measure of a spool type positioner’s dirt tolerance is to compare the manufacturer’s recommended filtration and bleed rates. For example, a unit with 0.6 std. ft^3/min bleed requiring 30 µm filtration will be more dirt tolerant and freeze resistant than a positioner with 0.2 std. ft^3/min bleed requiring 3 µm filtration. Many users choose the previous method after weighing the cost of unscheduled shutdowns vs. the cost of additional air consumption.

Vibration resistance and two-stage pneumatics

By using the above-mentioned technologies to replace the traditional spool valve, vibration resistance improves by an order of magnitude, and positioner orientation is a nonissue. Even with proper orientation of spool type positioners, two-stage electro-pneumatic positioners—providing excellent performance—are still vulnerable to vibration due to the sensitivity of the current to pressure (I/P) conversion element. One manufacturer claims to have overcome this problem by replacing traditional single-stage pneumatic positioners with a two-stage pneumatic positioner design and remote mounted I/P transducer. The two-stage pneumatic positioner provides superior speed and accuracy. Reliability of the system improves with the I/P transducer isolated from the valve.

As with any remote mounted I/P installation, air tubing from the I/P to the positioner should be neither too short nor too long. If it is too short, the positioner may become unstable. Coiling up and connecting 10 ft of 0.25-in. tubing will usually stabilize the system. In no case should 0.25-in. tubing lengths exceed 100 ft. One manufacturer's tests indicated no degradation of dead time or speed with interconnecting tubing lengths up to 30 ft. One should consider longer lengths carefully before installation to ensure maximum performance.

ACCURACY

With several "smart" digital positioners on the market, note that many still use a precision potentiometer to provide valve position feedback with an analog to digital (A/D) converter added to provide digital output. While this method improves precision, it has a limitation due to the inherent accuracy of the analog potentiometer.

One manufacturer overcomes this limitation with an innovative design using an integral optical encoder to measure valve stem position as **Fig. 3** shows. This unique concept provides truly digital measurement of the valve position with a resolution and digital repeatability of 0.002 in. Coupled with digital outputs, this approach makes it a true digital positioner.

SMART POSITIONERS

Still begging for a universal, standard definition of "smart," microprocessor-based positioners basically offer powerful diagnostic tools. These provide the capability to predict rather than react to positioner and valve maintenance needs. Digital positioners can provide complete information on the control valve dynamics, display nearly real-time diagnostics, and pinpoint the problem area in the valve assembly or positioner.

Downtime, maintenance costs, and length of scheduled outages can decrease dramatically with this ability to identify easily only those control valves and positioners that need maintenance. Identifying degenerating positioners and valves long before they fail also minimizes unscheduled outages and their frequency and duration. With built-in user-defined alerts, the positioner does not require constant operator monitoring. This allows console operators to concentrate on the process status. Self-monitoring and automatic alerts provide proactive maintenance and allow more efficient use of maintenance resources. The following are a few selected diagnostics that help achieve increased efficiency:

- Auto-tune: Operator initiates a pre-programmed calibration procedure that quickly tunes the positioner to the specified control signal.
- Step response: This automatically runs a multipoint travel vs. time test measuring the valve's dynamic response. It displays its dead time, response speed, and overshoot. Storing the valve's original—new—footprint allows future comparison of prior and current performance, giving instant information on any performance degradation.
- Dynamic response: This runs a signal vs. travel test measuring and displaying the valve's linearity, hysteresis, and total accuracy.
- Valve assembly signature: Actuator pressure vs. travel testing determines the assembly's friction, bench set, spring rate, and seat loading—valve leakage issue.
- Instrument status: This displays the status of internal positioner diagnostic tests.
- Travel accumulator: This records total accumulated travel that can predict packing or valve maintenance requirements.

Self-monitoring alerts include travel alerts, cycle alerts, travel cut off, position deviation alerts, drive signal alerts, restart control modes, self-test shutdown, and many others. Self-monitoring of critical performance characteristics with built-in alerts is similar to having hundreds of technicians constantly observing every valve's performance and reporting data or deviations from normal operation. The advantages of using "smart" electronic technicians instead are obvious. If the term "smart" continues in use for these instruments, would it be unreasonable for future standards to specify instrument IQs (pronounced "iiks" for short)? With most smart positioners already on the market, it is becoming more difficult to determine which is best for a given application.

COMMUNICATION PROTOCOLS

Several different brand-dependent protocols and other proprietary protocols are in use. Most units claim to be field-bus convertible with one or two already on the market using field-bus protocol. Trends in the industry favor a particular instrument on retrofits because there are several manufactures from which to choose. Communication is possible using commercially available hand-held communicators with the positioners operating on a standard 4–20 ma, two-wire signal. This eliminates the need for rewiring.

CONCLUSIONS

As always, new technologies create new issues for solution over time. Positioners today have made a quantum leap in performance and capability over their older cousins from 20 years ago. Using new, noncontact position sensing technologies such as lasers, microwaves, or ultrasonics coupled with advanced microprocessors, future positioners will make today's smart positioners appear quite dumb by comparison. While positioners may never reach perfection, they will continue to approach that goal if end users demand it. **TJ**

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